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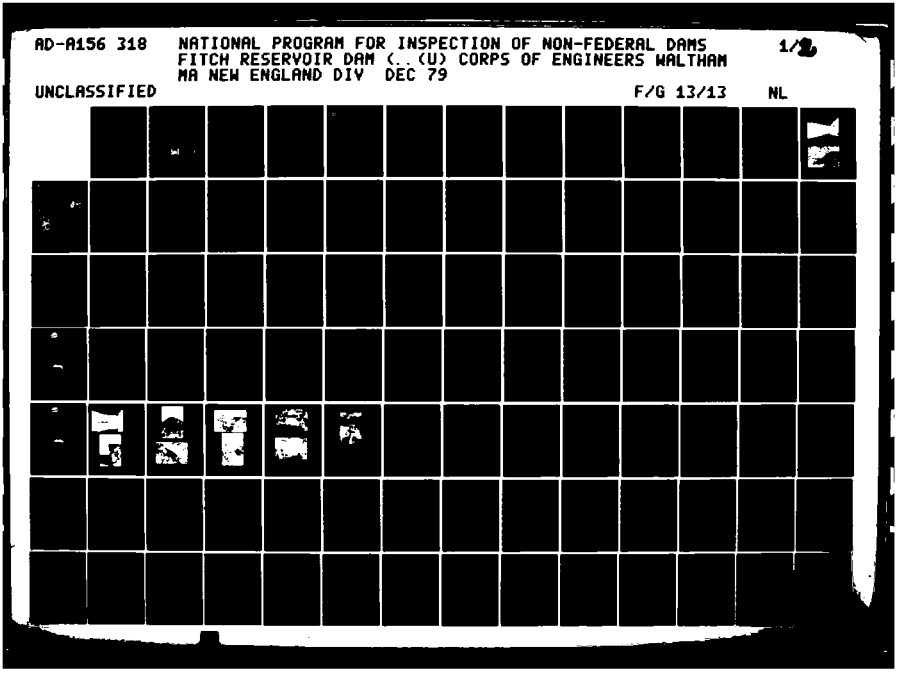

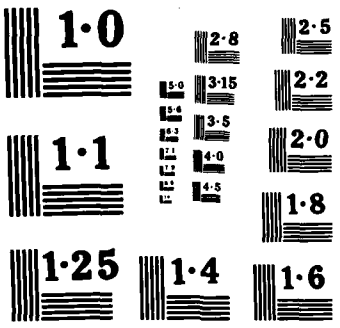

(1)

CONNECTICUT RIVER BASIN
CLAREMONT, NEW HAMPSHIRE

FITCH RESERVOIR DAM
NH 00142
NHWRB 42.16

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

DECEMBER 1979

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NH 00142	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* Fitch Reservoir Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254		12. REPORT DATE December 1979 13. NUMBER OF PAGES 72
14. MONITORING AGENCY NAME & ADDRESS(*if different from Controlling Office*)		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

DAMS, INSPECTION, DAM SAFETY,

Connecticut River Basin
Claremont, New Hampshire
Grandy Brook, a tributary of the Sugar River(tributary of the Conn. River)

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The dam is an earth embankment, about 300 ft. long and 40 ft. high, with a 6 ft. wide channel spillway. Lives in the houses would be threatened by a dam failure. It is intermediate in size with a high hazard category. The test flood for the dam is the PMF. THe dam is in fair condition at the present time. Further incestigations are recommended to evaluate the adequacy of the spillway and the stability of the downstream slope.

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF
NEDED

JAN 25 1980

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen:

Inclosed is a copy of the Fitch Reservoir Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, the town of Claremont.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

FITCH RESERVOIR DAM
NH 00142

CONNECTICUT RIVER BASIN
SULLIVAN COUNTY, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

PHASE I REPORT

Identification No.:	NH 00142
NHWRB No.:	47.16
Name of Dam:	FITCH RESERVOIR DAM (formerly Johnson Reservoir)
Town:	Claremont
County and State:	Sullivan County, New Hampshire
Stream:	Grandy Brook, a tributary of the Sugar River, which is a tributary of the Connecticut River
Date of Inspection:	August 21, 1979

BRIEF ASSESSMENT

The Fitch Reservoir Dam is located on Grandy Brook, approximately 2 miles upstream of Claremont, New Hampshire. The dam is an earth embankment, approximately 300 feet long and 40 feet high, with a 6 foot wide rock channel spillway. There are two outlet gates at the downstream toe which are used to release water to maintain the water level in the McQuade Reservoir which is just downstream of this dam.

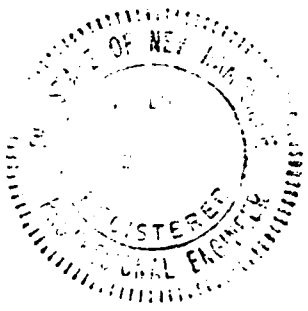
The water impounded by this dam is presently used for water supply by approximately 15 houses in Claremont, New Hampshire. The dam is owned by the Town of Claremont.

The drainage area of the dam covers 0.8 square miles of rolling and mountainous woodland. The dam normally impounds 75 acre-feet and has a maximum impoundment of 87 acre-feet. The dam's 40-foot height places it in the intermediate size category. The hazard classification is high because of the potential damage to two downstream dams, two commercial buildings and up to seven houses. Lives in the houses would be threatened by dam failure.

The Test Flood for this dam is the Probable Maximum Flood (PMF). The peak inflow for this flood would be 2,070 cfs and the resulting peak outflow would be 2,025 cfs. The water level would be at elevation 1031.5 feet (MSL) which would overtop the dam by 1.5 feet. The spillway capacity is inadequate to pass the routed test flood. Its discharge capacity at top of dam (elev. 1,03[illegible] is 238 cfs, or only 12 percent of the routed test flood peak outflow.

The dam is in FAIR condition at the present time. Further investigations are recommended to evaluate the adequacy of the spillway and the stability of the downstream slope. Remedial measures to be undertaken by the owner include: rehabilitating the 24 inch gate, repairing the gate house, reconstructing the masonry end wall at the crest, redecking the timber footbridge, removing the shrubs and saplings by the roots and filling in the resulting voids, implementing a program of periodic maintenance and inspection, and developing a formal written downstream emergency system.

The remedial measures outlined above should be implemented within one year of receipt of this report by the owner.



William S. Zoino
N.H. Registration No. 3226

Nicholas A. Campagna, Jr.
California Registration 21006

This Phase I Inspection Report on Fitch Reservoir Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgement and practice, and is hereby submitted for approval.

JOSEPH W. FINEGAN, JR., MEMBER
Water Control Branch
Engineering Division

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

JOSEPH A. MCELROY, CHAIRMAN
Chief, NED Materials Testing Lab.
Foundations & Materials Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the Test Flood should not be interpreted as necessarily posing a highly inadequate condition. The Test Flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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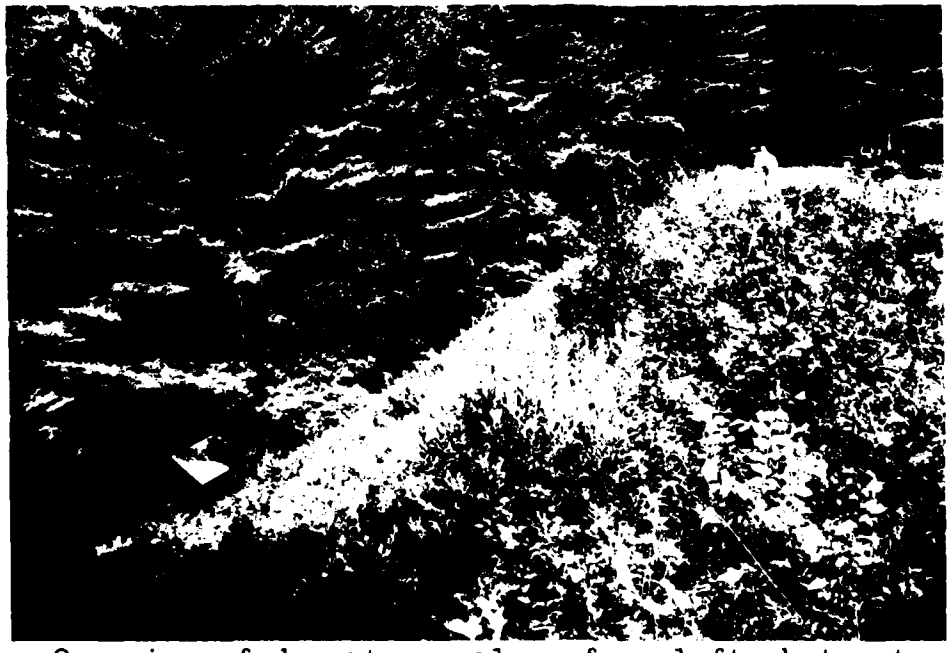
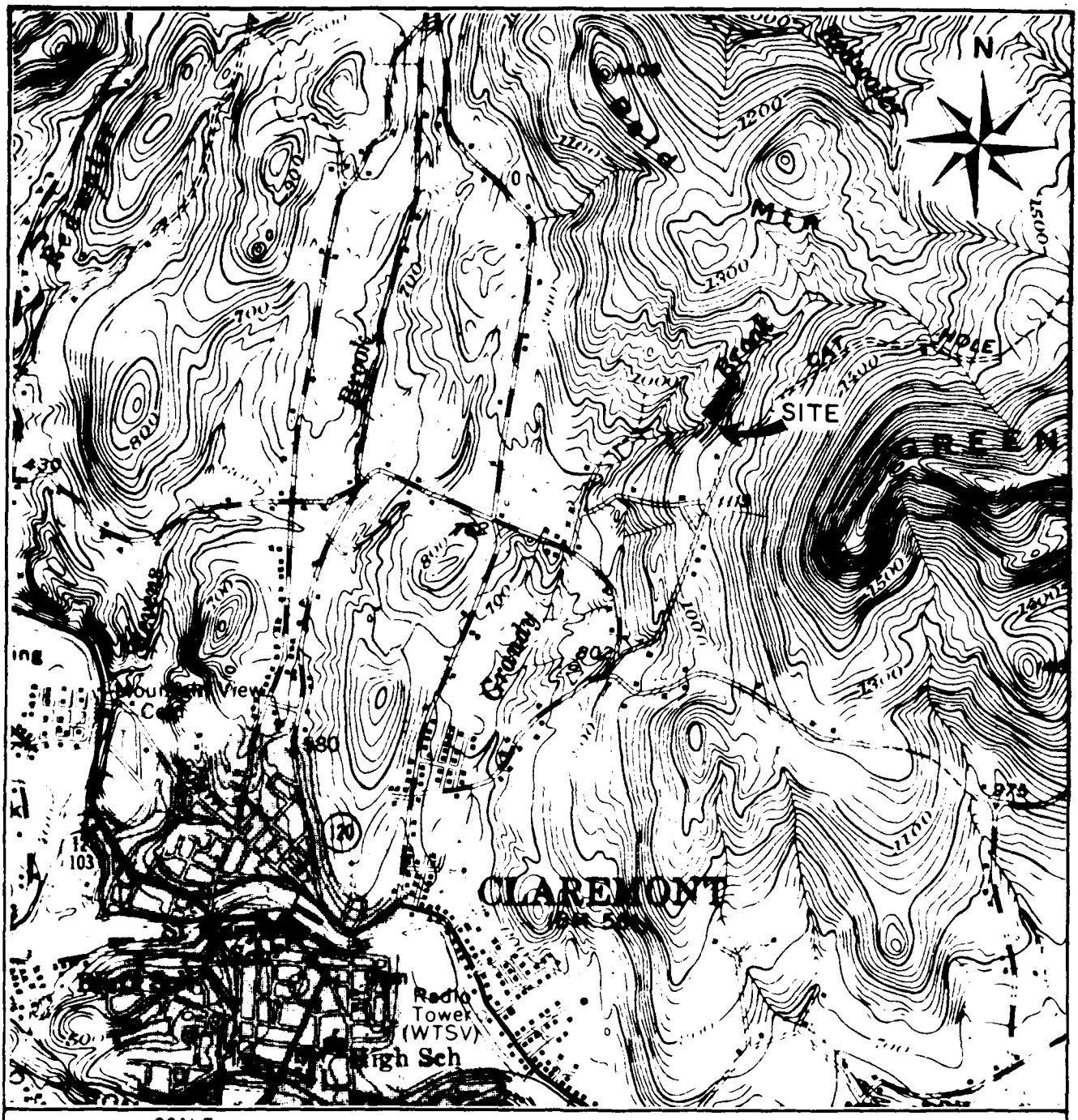
Overview from upstream side



Overview of downstream slope from left abutment



– SCALE –

0 1/4 1/2 1 (MILES)

FROM: USGS CLAREMONT - N.H. QUADRANGLE MAP

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC GEOTECHNICAL CONSULTANTS NEWTON UPPER FALLS, MASS.	U.S. ARMY ENGINEER DIV NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCUS PLAN

FILE No. 2327

FITCH RESERVOIR DAM — CLAREMONT, NEW HAMPSHIRE

			SCALE AS NOTED
			DATE SEPT. 1979

V

1.2 Description of Project

(a) Location

The Fitch Reservoir Dam is located on Grandy Brook approximately 2 miles upstream of Claremont, New Hampshire. It can be reached from town roads which intersect Routes 11 and 103 in Claremont, New Hampshire. The dam is shown on U.S.G.S. Claremont New Hampshire-Vermont Quandrangle with coordinates approximately at N43° 24.0', W72° 18.8' (see location map on page v). Page B-2 of Appendix B is a site plan for this dam.

(b) Description of Dam and Appurtenances

The dam consists of an earth embankment with a wood-sheet pile core wall and a spillway cut into rock in the left abutment. The embankment is 300 feet long and the spillway is approximately 6 feet wide.

1) Embankment (See pages B-2, B-3 and B-9)

The embankment is 300 feet long and a maximum of 40 feet high. The upstream slope is 2 horizontal to 1 vertical with riprap. The downstream slope is 1.5 horizontal to 1 vertical. The crest width is 14 to 16 feet. According to available plans there is a core wall consisting of two rows of tongue and groove pine sheet piling, two feet apart, with puddled clay in between.

2) Outlets

At the downstream toe of the dam there is a wood framed gate house supported on a cemented stone masonry foundation. The gate operator consists of an inclined bench stand with a hand operated wheel. This bench stand, when operated, would activate rack gears designed to open the non-rising stem gate. The outlet of this gate is a 24 inch diameter cast iron pipe which terminates 5 feet downstream at a "U" shaped headwall, which is approximately 4 feet wide at the top and is constructed of cemented stone masonry. The end walls are constructed of dry stone masonry.

Approximately 3 feet to the left of the gate house is a gate valve which is operated by means of a hand wrench. This wrench is stored in the gatehouse. The outlet of this gate is an 8 inch diameter cast iron pipe which terminates approximately 15 feet downstream of the gatehouse and discharges into the spillway channel.

3) Spillway (See pages B-2, B-3 and B-9)

The spillway is a broad crested rock channel which was excavated in the left abutment. It curves to the right around the embankment and lies approximately 4.5 feet below the top of the dam. The control section is approximately 6 feet wide and the side slopes are steep and rough. There is a narrow wood footbridge over this spillway at the dam crest.

4) Foundation and Embankment Drainage

Available plans and the visual inspection do not reveal any evidence of a foundation drainage system for this dam.

(c) Size Classification

The dam's maximum impoundment of 87 acre-feet and height of 40 feet place it in the intermediate size category according to the Corps of Engineers' Recommended Guidelines. The height between 40 and 100 feet places it in the intermediate size category.

(d) Hazard Potential Classification

The hazard potential classification for this dam is HIGH because of the potential for economic loss and loss of life downstream in the event of a dam failure. Lives would be threatened in up to seven downstream houses and two dams would be damaged. Also some minor flooding of an ambulance garage and furniture store would occur. Section 5 of this report presents more detailed discussion of the hazard potential.

(e) Ownership

The dam is owned by the Town of Claremont, New Hampshire. It is overseen by the Claremont Water Works Department, 45 Crescent Street, Claremont, New Hampshire 03743. They can be reached by telephone at (603) 542-6691.

(f) Operator

The operation of the dam is controlled by the Claremont Water Works Department, Claremont, New Hampshire 03743. The Department's telephone number is (603) 542-6691.

(g) Purpose of the Dam

At the present time, the reservoir is used to maintain the water level in McQuade Reservoir just downstream. This reservoir is used for water supply for approximately 15 houses in the Town of Claremont, New Hampshire. According to the Claremont Water Department, these reservoirs will be eliminated from the water supply system within the next few years. The town is investigating the possibility of using them for recreational purposes.

(h) Design and Construction History

According to available records the Fitch Reservoir Dam, formerly known as Johnson Reservoir Dam, was first constructed in 1888. The addition of the McQuade Reservoir, formerly known as Phelps Reservoir, was accomplished in 1899.

(i) Normal Operating Procedure

The Claremont Water Works Department checks the water levels in both Fitch Reservoir and McQuade Reservoir (which is just downstream) at least once per week. When necessary to maintain the required water level in McQuade Reservoir, the 8 inch gate is opened to release water from Fitch Reservoir, The 24 inch gate has not been operated for at least 5 years. Maintenance is performed on a "as-needed" basis.

1.3 Pertinent Data

(a) Drainage Area

The drainage area for this dam covers approximately 0.8 square miles. It is made up primarily of rolling and mountainous woodland.

(b) Discharge at Damsite

1) Outlet Works

There are two outlets from this reservoir. There is an 8 inch diameter pipe equipped with a gate which outlets at the downstream toe of the dam. This gate is operated periodically to maintain the water level in McQuade Reservoir. There is a 24 inch diameter pipe equipped with a gate which outlets next to the 8 inch pipe. This gate has not been operated in the recent past.

2) Maximum Known Flood

There is no data available for the maximum flood at this damsite.

3) Ungated Spillway Capacity at Top of Dam

The capacity of the spillway with the reservoir at the top of dam elevation (1,030 feet MSL) is 238 cfs.

4) Ungated Spillway Capacity at Test Flood

The spillway discharge capacity at test flood elevation 1,031.5 is 400 cfs.

5) Gated Spillway Capacity at Normal Pool

There are no gated spillways. The gated pond drain inlet is normally closed.

6) Gated Spillway Capacity at Test Flood

As previously mentioned, there are no gated spillways.

7) Total Spillway Capacity at Test Flood

The total spillway discharge capacity at test flood elevation 1,031.5 is 400 cfs.

8) Project Discharge at Test Flood

The total project discharge at test flood elevation (1,031.5 feet MSL) is 2,025 cfs.

(c) Elevation (feet above MSL)

1) Streambed at centerline of dam: 990±

2) Maximum tailwater: Unknown

3) Upstream portal invert diversion tunnel: Not applicable

4) Normal pool: 1,025.5±

5) Full flood control pool: Not applicable

6) Spillway crest: 1,025.5

7) Design surcharge: No data

8) Top dam: 1,030±

(d) Reservoir

1) Length of maximum pool: 1,100± feet

2) Length of normal pool: 1,100± feet

3) Length of flood control pool: Not applicable

(e) Storage (acre-feet)

1) Normal pool: 74

2) Flood control pool: Not applicable

3) Spillway crest pool: 74

4) Top of dam: 87

5) Test flood pool: 92

(f) Reservoir Surface (acres)

1) Normal pool: 3

2) Flood control pool: Not applicable

3) Spillway crest pool: 3

4) Test flood: 3

4) Top of dam: 3

(g) Dam

1) Type: Earth embankment with riprap on upstream slope

2) Length: 300 feet

3) Height: 40 feet

4) Top width: 16± feet

5) Side slopes: Upstream: 2 to 1
Downstream: 1.5 to 1

6) Zoning: No data, believed to be homogeneous

7) Impervious core: 2 walls of tongue and groove pine sheeting enclosing puddled clay

8) Cutoff: No data

9) Grout curtain: No data

(h) Diversion and Regulating Tunnel

Not Applicable

(i) Spillway

1) Type: Broad crested channel blasted in rock in the left abutment

2) Length of weir: 6 feet

3) Crest elevation: 1,025.5 feet (MSL)

4) Gates: None

5) Upstream channel: Reservoir

6) Downstream Channel: Steep rock channel

(j) Regulating Outlet

The regulating outlet is an 8 inch diameter sluice gate. The invert elevation of this outlet is unknown. It is used to release water from this reservoir in order to maintain the water level of McQuade Reservoir which is located just downstream.

There is a 24 inch diameter pipe equipped with a gate. This gate is believed to be closed but it has not been operated for at least 5 years.

SECTION 2 - ENGINEERING DATA

2.1 Design Data

The only design data available is a drawing, dated 1899, by George S. Rice and George E. Evans, Engineers. This drawing shows a plan of the existing Johnson Reservoir Dam (Fitch) and the proposed Phelps Reservoir Dam (McQuade). A copy of this drawing is contained in Appendix B of this report. The original drawing is in the possession of the Claremont Water Works Department, Claremont, New Hampshire.

The New Hampshire Water Resources Board maintains a file on this dam including inspection reports dated 1937, 1938, and 1939. These reports contain sketches or descriptions of the dam. These reports are shown in Appendix B of this report.

2.2 Construction Data

No construction records are available for the dam.

2.3 Operational Records

The Claremont Water Works Department maintains impoundment records for this dam.

2.4 Evaluation of Data

(a) Availability

The lack of detailed design and construction data warrants an unsatisfactory assessment for availability.

(b) Adequacy

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing the design and construction data. This assessment is thus based primarily on the visual inspection, past performance, and sound engineering judgement.

(c) Validity

Since the observations of the inspection team generally confirm the information contained in the records of the New Hampshire Water Resources Board and the Claremont Water Department, a satisfactory evaluation for validity is indicated.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

(a) General

The Fitch Reservoir Dam is in FAIR condition at the present time.

(b) Dam

1) Embankment (Photos No. 2,3, and 4)

The alignment of the dam along the crest is generally good to slightly irregular. The irregularities are due to the manner of construction and are not attributed to movement of the crest.

The riprap on the upstream slope is in fair to good condition with no major problems existing. Above the water line there is heavy grass growth.

The downstream slope is covered with heavy brush growth. This slope is approximately 1.5 horizontal to 1 vertical.

Some seepage was noted at two areas on the downstream toe near the left abutment. These areas are obscurred by heavy brush growth and flow volumes could not be estimated.

Approximately 65 feet down the slope from the crest, there is a break in the slope of approximately 2 feet. This irregularity represents approximately the lower 20 percent of the slope.

2) Spillway (Photos No. 5 and 6)

A 6 foot wide, broad crested channel has been blasted out of the rock of the left abutment. The rock is phyllite with cleavage approximately parallel to the axis of the dam. The spillway is generally in fair condition with the exception of some stones which have fallen into the channel from the dry stone masonry sidewall on the embankment side of the upstream end of the spillway.

(c) Appurtenant Structures (Photo No. 7,8, and 9)

The wood framed gate house is in poor condition with an advanced degree of rot on the wood floor. The wood siding shows evidence of rot. The door of this structure is broken and the structure is prone to vandalism. The gearing system attached to the bench stand, for operating the 24-inch gate, is completely rusted. It is doubtful that this gate can be operated without complete rehabilitation. Discussions with personnel of the Claremont Water Works revealed that this gate has not been operated in the past five years and possibly once in the preceeding ten years. The 8-inch gate valve is operable and at the present time is partially opened. The rate of discharge at the time of inspection was 2 to 3 g.p.m.

The "L" shaped training wall located adjacent to the spillway at the left end of the earth embankment consists of dry stone masonry. This masonry has unravelled at numerous locations.

The timber footbridge over the spillway varies from 6 to 8 feet in width, is in fair condition, and provides an access to the gatehouse. Spaces between planks vary in width from 3 to 8 inches. There are no hand rails.

(d) Reservoir Area (Photo No. 1)

The shore of the reservoir is generally shallow sloping woodland. It appears stable and in good condition with the exception of some minor shallow sloughing approximately 200 feet upstream of the right abutment.

(e) Downstream Channel

The rock channel slopes steeply down the left abutment to the natural streambed which runs to the McQuade Reservoir immediately downstream (400 to 600 feet). The channel appears stable and in good condition.

3.2 Evaluation

The dam and it appurtenances are in fair condition at the present time. The potential problems observed during the visual inspection are listed below:

(a) Heavy brush growth on the downstream slope of embankment.

(b) Seepage areas at downstream toe of embankment.

(c) Questionable operating condition of both outlet gates.

(d) Gate house in serious disrepair.

(e) Stone masonry end wall at the left end of the embankment crest is in disrepair.

(f) Footbridge over spillway in poor condition.

(g) Irregularity and steepness of the downstream slope of embankment.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Operational Procedures

No written operational procedures exist for this dam. It is operated as necessary to maintain the water level in the McQuade Reservoir downstream.

4.2 Maintenance of Dam

Maintenance of the dam is performed on an "as needed" basis by the Claremont Water Works Department. No maintenance program exists for the dam.

4.3 Maintenance of Operating Facilities

No maintenance program exists for the operating facilities of this dam. The 8 inch pond drain gate is operated periodically but the 24 inch gate has not been operated for at least 5 years.

4.4 Description of Warning System

There is no warning system in effect.

4.5 Evaluation

The dam's present condition is a direct result of the lack of a maintenance program for the dam. Repair of the operating facilities and clearing of the embankment slopes need to be accomplished.

SECTION 5 - HYDROLOGY/HYDRAULICS

5.1 Evaluation of Features

(a) General

Fitch Reservoir Dam, formerly known as Johnson Reservoir Dam, is an earthen embankment on Grandy Brook, a tributary of the Sugar River which is a tributary of the Connecticut River. The dam is located about three miles upstream of the confluence of Grandy Brock and the Sugar River, in the City of Claremont, New Hampshire. The drainage area upstream of the dam is 0.81 square miles.

There are two outlets controlled by gate valves at a gatehouse downstream of the dam, an 8 inch cast iron pipe and a 24 inch cast iron pipe. These outlets are normally closed. The spillway is a six foot channel blasted in rock on the right abutment. The spillway crest is about 4.5 feet below the dam crest.

(b) Design Data

Data sources available for Fitch Reservoir Dam include prior inventory and inspection reports. Much of the basic data for the dam is contained in the New Hampshire Water Control Commission's "Data on Dams in New Hampshire" (November 9, 1938) and the New Hampshire Water Resources Board's "Inventory of Dams and Water Power Developments" (1925). An inspection report dated June 30, 1930 is available as is a 1899 plan of the area showing a proposed downstream reservoir and a September 26, 1939 sketched plan and elevation of the dam.

Correspondence from the New Hampshire Water Resources Board to the Claremont Water Works discussing an October 1975 storm and suggesting that the spillway be enlarged is also available.

(c) Experience Data

No records of flow are known to be available for Fitch Reservoir Dam. The Claremont Water Works Department maintains an intermittent record of reservoir stage based on visual observations. The stage and flow of the flood of record are unknown. The 1938 hurricane flood caused damage to the embankment, and a 1975 storm caused a high stage in the pond, prompting the New Hampshire Water Resources Board to suggest that the spillway be enlarged.

(d) Visual Observations

The spillway is a broad-crested channel blasted in the rock ledge of the right abutment. Its crest is 4.5 feet below the dam crest, at elevation 1,025.5 feet MSL. The controlling section of the channel is 6 feet wide at the spillway crest, and increases to 13 feet at the dam crest elevation. Beyond the control section the rock channel slopes very steeply down the dam's right abutment to Grandy Brook immediately downstream.

There are two outlets at Fitch Reservoir Dam -- an 8 inch and a 24 inch cast iron pipe. Both run through the embankment and are controlled by gate valves in a gatehouse on the downstream toe of the dam. The elevations of the upstream inverts of these pipes are unknown -- the downstream inverts are about 40 feet below the dam crest, at 990 feet MSL.

The 8 inch line is a water supply outlet and is opened periodically during the dry season to release water to fill McQuade Reservoir. This operation occurs every two to three weeks during the summer. The 24 inch pipe is a pond drain outlet and is seldom used. According to a representative of the Claremont Water Works, it has not been operated in at least 5 years.

Downstream of the dam, Grandy Brook runs through a steep, narrow channel for 1,200 feet to McQuade Reservoir. There is no development in this reach.

McQuade Reservoir has a surface area of about one acre, and is created by a 150 foot long earth embankment with a 12.5 foot broadcrested concrete spillway and 2.5 feet of freeboard. This reservoir supplies water for the City of Claremont.

From McQuade Reservoir, Grandy Brook runs 2,200 feet to a residential street in Claremont. The slope in this reach is less steep, and the stream widens out some. Near the upstream end of this reach Grandy Brook is crossed by a dirt road with a 48 inch culvert. There are two houses near this road -- one 12 to 13 feet above the streambed and one 8 feet up. Four other houses in this reach are 20 to 25 feet above the stream.

The residential street crosses Grandy Brook on a 16 foot high embankment with a 48 inch culvert. Downstream of this crossing the stream runs for 4,500 feet through an undeveloped area to a small pond about 200 feet upstream of a second residential street.

The pond is created by an earth embankment with a concrete spillway. The embankment is in very poor condition, and has several low spots in different areas. Downstream of this dam to the southwest, there is a group of 4 to 5 houses at spillway level.

After the road crossing 200 feet downstream of this pond, the brook runs 2,500 feet through a small reservoir to another road crossing at Highway 11/103. There are 3 houses 6 to 12 feet above the streambed and a furniture store and ambulance garage 15 feet up at this crossing. The highway crosses on an 11 foot high bank with a 60 inch culvert.

About 200 feet downstream of this road crossing, Grandy Brook enters the Sugar River.

(e) Test Flood Analysis

The hydrologic conditions of interest in this Phase I investigation are those required to assess the dam's overtopping potential and its ability to safely allow an appropriately large flood to pass. This requires using the discharge and storage characteristics of the structure to evaluate the impact of an appropriately sized Test Flood. None of the original hydraulic and hydrologic design records are available for use in this study.

Guidelines for establishing a recommended Test Flood based on the size and hazard classification of a dam are specified in the "Recommended Guidelines" of the Corps of Engineers. The impoundment of less than 50,000 acre-feet and the height of between 40 and 100 feet classify this dam as an INTERMEDIATE structure.

The appropriate hazard classification for this dam is HIGH because of the significant economic losses and potential for loss of life downstream in the event of dam failure. As shown in the Dam Failure Analysis section, the increase in flooding caused by failure would pose a threat to property and to lives along Grandy Brook in the City of Claremont. Other impacts of dam failure include possible damage to a well-traveled highway, to residential streets, and to McQuade Reservoir (see Dam Failure Analysis section).

As shown in Table 3 of the Corps of Engineers' "Recommended Guidelines", the appropriate Test Flood for a dam classified as INTERMEDIATE in size with a HIGH hazard potential would be the probable maximum flood (PMF). Using the Corps of Engineers, New England Division's "Maximum Probable Flood Peak Flow Rates" for a drainage area of 520 acres (.81 square miles), yields a peak PMF inflow of 2,550 csm which is 2,070 cfs. Use of the Corps' suggested methodology for determining attenuation by storage in the reservoir results in a peak outflow of 2,025 cfs, with the water surface at about 1,031.5 feet MSL, 1.5 feet above the dam crest and 6 feet above the spillway crest. The spillway capacity with the water surface at the top of dam is 238 cfs, or 12 percent of the routed test flood peak outflow. The estimated 100-year outflow of 250 cfs is 8 percent greater than the spillway capacity. At one-half PMF outflow (1,015 cfs) the water surface would be 0.8 feet above the dam crest.

(f) Dam Failure Analysis

The peak outflow that would result from the failure of Fitch Reservoir Dam is estimated using the procedure suggested in the Corps of Engineers, New England Division's April 1978 "Rule of Thumb Guidelines for estimating Downstream Dam Failure Hydrographs". Failure is assumed to occur with the water surface elevation at the dam crest, 1,030 feet MSL, 4.5 feet above the spillway crest.

The discharge just prior to failure at the elevation is given by the Stage-Discharge curve developed in Appendix D as 238 cfs. The tailwater prior to failure at this discharge is estimated to be 2 feet of flow in Grandy Brook.

For an assumed breach width equal to 40 percent of the dam width at the half-height, the gap in the embankment due to failure would be 80 feet. The resulting increase in flow would be 31,500 cfs or a total of about 31,700 cfs. This would increase the tailwater by 14 feet to about 16 feet of flow.

The first downstream development impacted by dam failure flows would be McQuade Reservoir, about 1,200 feet from Fitch Reservoir Dam. The pre-failure flow of 240 cfs would just overtop the McQuade dam crest. The attenuated peak dam failure flow of 22,500 cfs would be about 10 feet over the dam crest and would severely damage or destroy the embankment.

About 500 feet downstream of McQuade Reservoir Dam there are two houses 8 and 12 to 13 feet above the streambed. The peak dam failure flow of about 20,000 cfs at this location would increase the stage from 2 feet to 13 feet, causing serious flooding with a severe threat of loss of life at the lower house. There is also a dirt road crossing which would be severely overtopped and damaged or destroyed by dam failure flows at this location.

For the remainder of the 2,200 foot reach from McQuade Reservoir Dam to a residential street in Claremont, the 4 houses are 22 to 25 feet above the streambed and out of danger. The street would be severely overtopped and probably damaged or destroyed by the attenuated peak dam failure flow of 13,500 cfs.

The next development to be impacted by dam failure flows is a small pond 4,500 feet downstream of the road crossing. The attenuated peak flood flow of 5,600 cfs would increase the stage in this pond from 2.4 feet over the spillway to 9 feet. This would severely overtop the pond's embankment, which is in very poor condition There are 4 to 5 houses to the southwest of this pond which would face severe flooding and possible loss of life as a result of dam failure flows. The potential for damage and loss of life would be greatly increased if the pond's embankment in this area were to fail.

The "scattering" of flow caused by this pond makes quantitative prediction of downstream flows difficult. There are two possible areas of impact. Two hundred feet downstream of the pond, Grandy Brook is crossed by a second residential street, which would be overtopped and possibly damaged by dam failure flows.

After a 2,500 foot reach in which the only development is a small reservoir on the brook, Grandy Brook is crossed by Highway 11/103. The road is on an 11 foot embankment with a 60 inch culvert, and might be overtopped and damaged by dam failure flows. There are 3 houses near this intersection, 6, 10, and 12 feet above the streambed, and a furniture store and ambulance garage 15 feet up at this location. These -- especially the lowest house -- might well be threatened by dam failure flows from Fitch Reservoir Dam.

About 200 feet downstream of this road crossing, Grandy Brook enters the Sugar River. Dam failure flows would quickly be attenuated in this larger stream.

The downstream effects of the failure of Fitch Reservoir Dam are summarized on the chart on the following page.

IMPACT OF DAM FAILURE CHART

Distance Downstream of Dam (ft)	Location	Number of Dwellings	Level Above Streambed (ft)	Flow and Stage Before Failure	Flow and Stage After Failure	Comments
-	Tailwater	-	-	238 cfs 2 feet	31,700 cfs 17 feet	
1200	McQuade Reservoir Dam	-	-	240 cfs .5 ft ± over dam	22,500 cfs 10 feet over dam	Probably damage or destroy dam.
1400 to 3000	Houses Downstream of McQuade	1 1 3	12-13 8 25+	240 cfs 2 feet	20,000 cfs ± 13 feet	Minor flooding at 1 house, severe with possible loss of life at second.
3400	First Road Crossing	1	22	240 cfs 16 feet (at road)	13,500 cfs 22 ft (6 ft over road if embankment holds	Serious overtopping of embankment - could be damaged or destroyed.
7900	Small Pond	Several Downstream of pond (4-5)	Spillway Level	250 cfs 2.5 feet over spill-way	5,600 cfs 9 feet over spillway	Severe overtopping of banks - possible failure. Flooding to houses downsteam, with some potential of loss of life.
8100	Second Road Crossing	-	-	240 cfs -	- -	Embankment overtopped.
10,200	Rt. 11/103 Crossing	1 1 1	6 10 12	240 cfs -	- -	Potential damage. Small chance for loss of life.

ambulance garage and furniture store

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

(a) Visual Observations

There has been no significant displacement or distress which would warrant the preparation of structural stability calculations, based on assumed sectional properties and engineering factors.

(b) Design and Construction Data

There are no plans or calculations of value to a stability assessment available for this dam.

(c) Operating Records

There are no known operating records for this dam.

(d) Post Construction Changes

There have been no known construction changes since the dam was completed.

(e) Seismic Stability

The dam is located in seismic zone No. 2 and, in accordance with the recommended Phase I guidelines, does not warrant seismic analysis.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

The Fitch Reservoir Dam is in FAIR condition at the present time.

(b) Adequacy of Information

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment is based primarily on the visual inspection, past performance, and sound engineering judgment.

(c) Urgency

The recommendations and improvements contained herein should be implemented by the owner within one year of receipt of the Phase I Report.

(d) Need for Further Investigation

Additional investigations should be performed by the owner as outlined in paragraph 7.2.

7.2 Recommendations

It is recommended that the Town of Claremont retain the services of a registered professional engineer to:

(a) Perform further hydrologic and hydraulic studies to determine the need for additional spillway capacity. The present capacity is seriously inadequate.

(b) Investigate the stability of the downstream slope of the embankment considering the steepness and evidence of seepage.

(c) Investigate the feasibility of putting the control valves on the upstream side of the dam.

The owner should implement the findings of the above engineering studies.

7.3 Remedial Measures

It is recommended that the owner institute the following remedial measures:

1) Rehabilitate the 24 inch gate.

2) Repair the gate house structure.

3) Reconstruct the dry stone masonry end wall at the left end of the crest.

4) Re-deck the timber footbridge across the spillway and install protective railing.

5) Remove shrubs and saplings, including their roots, from the slopes of the embankment. Backfill the resulting voids with suitable compacted material.

6) Implement and intensify a program of diligent and periodic maintenance including, but not limited to: mowing embankment slopes, backfilling drainage gullies or animal burrows with suitable, well tamped soil, and clearing debris from outlets and slopes.

7) Implement a program of annual technical inspections of the dam and its appurtenances including operation of all outlet works.

8) Develop a formal written downstream emergency warning system.

7.4 Alternatives

Breaching the dam is a possible alternative to the above measures.

APPENDIX A

INSPECTION CHECKLIST

INSPECTION TEAM ORGANIZATION

Date: August 21, 1979

Project: NH 00142
FITCH RESERVOIR DAM
Claremont, New Hampshire
NHWRB 47.16

Weather: Clear, Sunny, 75

INSPECTION TEAM

Nicholas A. Campagna	Goldberg, Zoino, Dunnicliff & Assoc., Inc. (GZD)	Team Captain
William S. Zoino	GZD	Soils
M. Daniel Gordon	GZD	Soils
Jeffrey M. Hardin	GZD	Soils
Andrew Christo	Andrew Christo Engineers (ACE)	Structures
Paul Razgha	ACE	Structures
Carl Razgha	ACE	Structures
Richard Laramie	Resource Analysis, Inc. (RAI)	Hydrology
Tom Gooch	RAI	Hydrology

Owner's Representative Present:

Bill Binder - Claremont Water Department
Russ Davis - Claremont Water Department
Gary Kerr - New Hampshire Water Resources Board Representative Present

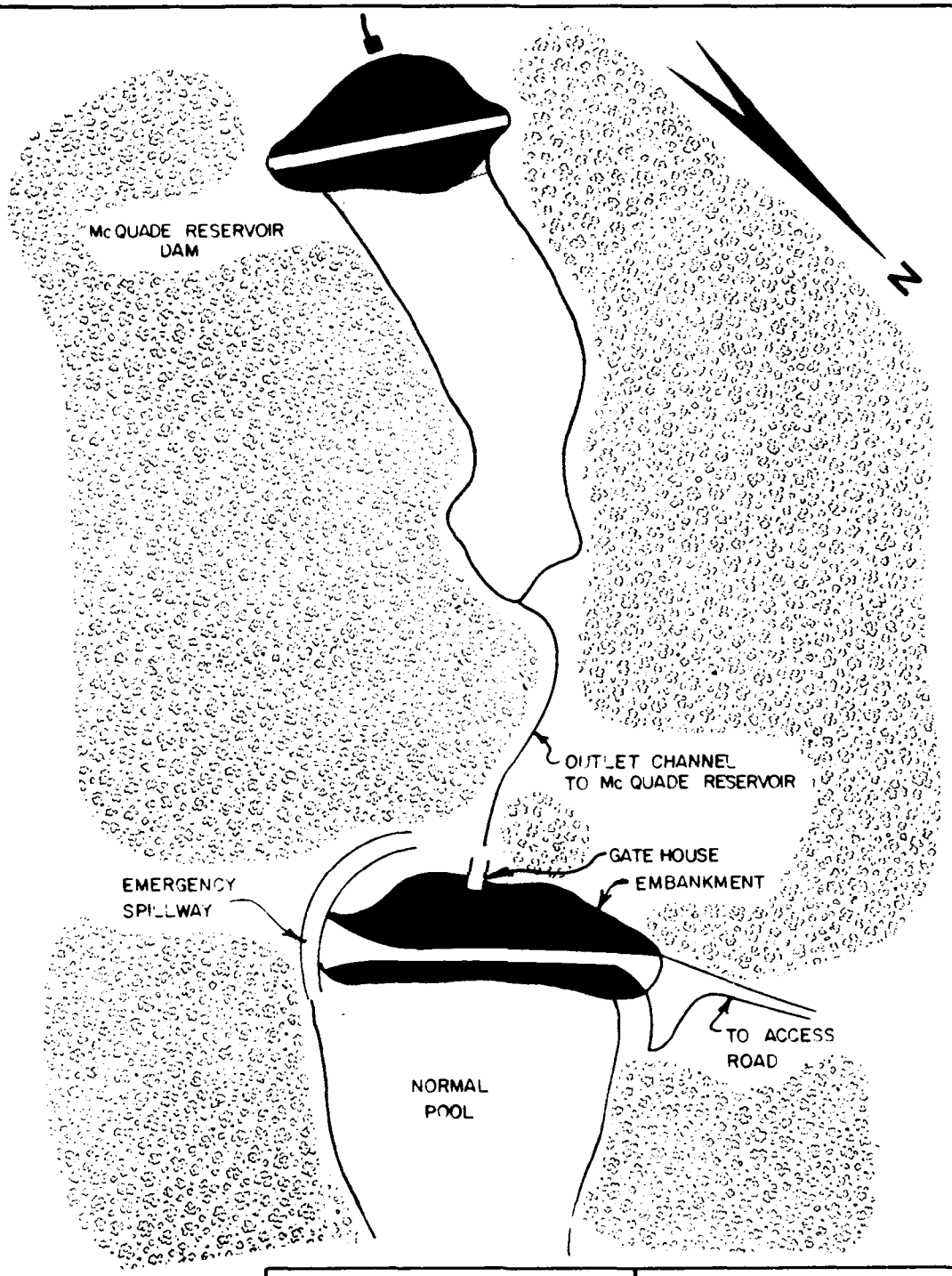
CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
EMBANKMENT		
Crest Elevation	nac	1030' Based on USGS Quad
Current Pool Elevation		1025'
Maximum Impoundment to Date		No Data
Surface Cracks		None
Pavement Condition		Not Applicable
Movement or Settlement of Crest		None
Lateral Movement		None
Vertical Alignment		Good
Horizontal Alignment		Good
Condition at Abutment and at Concrete Structures		Good
Indications of Movement of Structural Items on Slopes		None
Trespassing on Slopes		6" Diameter Animal Burrow in Downstream Slope Near Crest - Much Brush
Sloughing or Erosion of Slopes or Abutments		None
Rock Slope Protection - Riprap Failures		Riprap on Upstream Slope in Good Condition
Unusual Movement or Cracking at or near Toes		Break in slope with 2 foot drop approximately 65 feet down the slope at maximum section
Unusual Embankment or Downstream Seepage	nac	2 Areas on toe of Downstream Slope Show Signs of Seepage

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
Piping or Boils	NAC	None
Foundation Drainage Features		None
Toe Drains		None
Instrumentation Systems	NAC	None
APPURTANENT STRUCTURES		
Gate House	AC	Wood sidewalls exhibit minor degree of rot. Wood plank floor rotted. Cemented stone masonry foundation in good condition.
24-inch Waste Gate		Gear system badly rusted and inoperable. No deficiencies noted for hand wheel and bench stand.
8-inch Waste Gate		No deficiencies noted
Headwall		No deficiencies noted
Left End Wall		Dry stone masonry unravelled
Timber Footbridge	AC	Spaces between planking vary from 3 to 8 inches. No railing.

APPENDIX B



GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC GEOTECHNICAL CONSULTANTS NEWTON UPPER FALLS, MASS	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MASS.

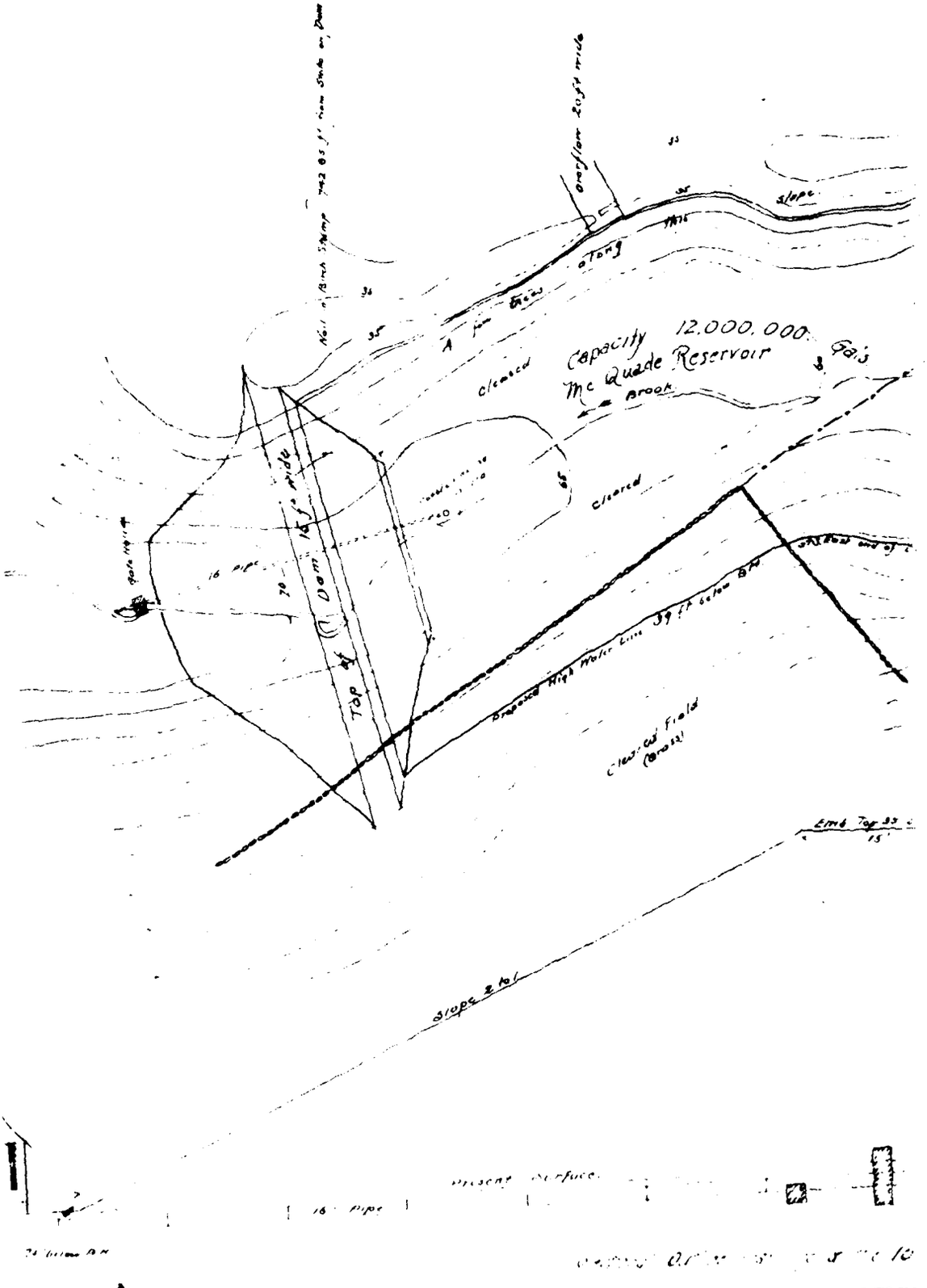
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

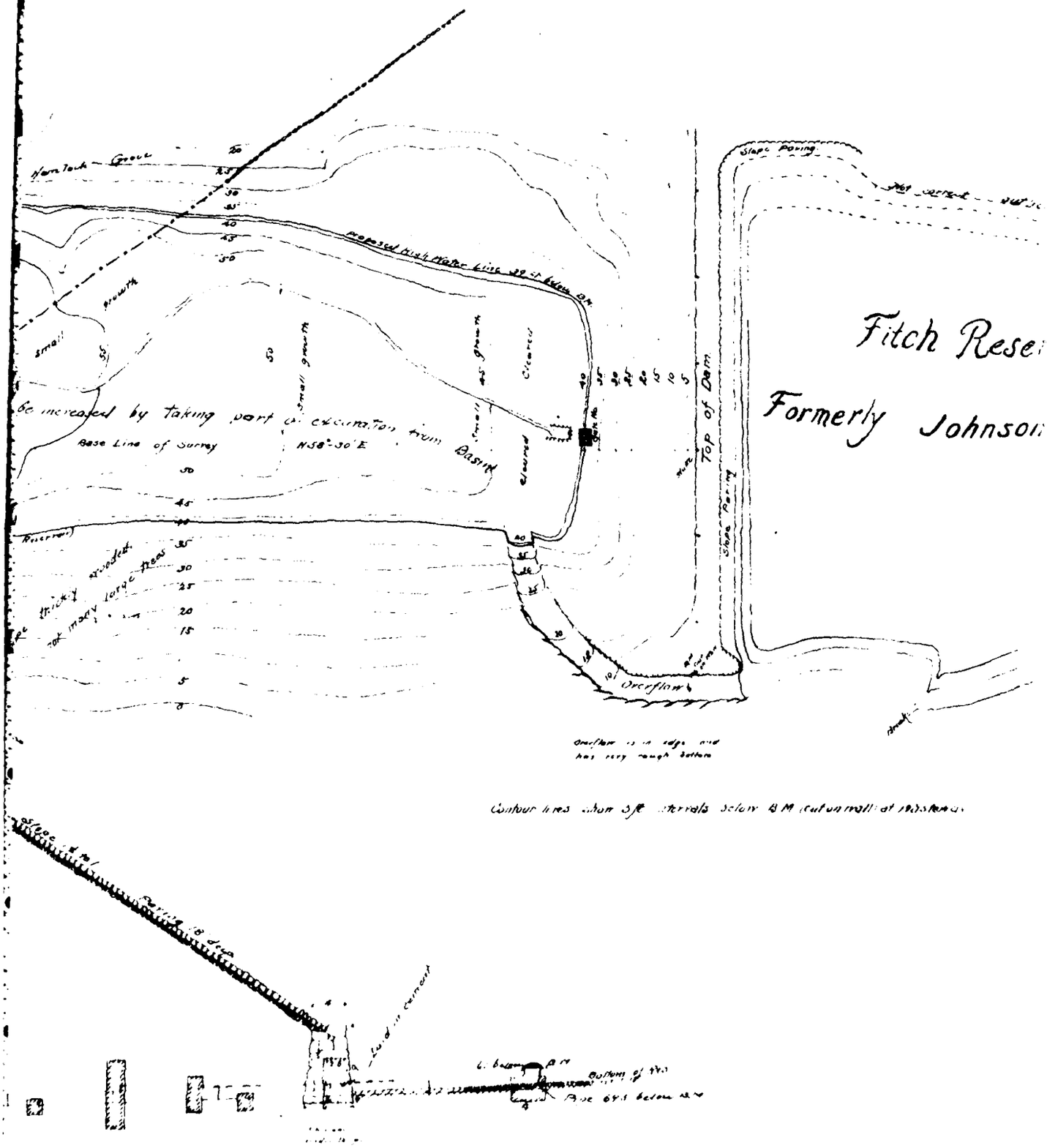
SITE PLAN

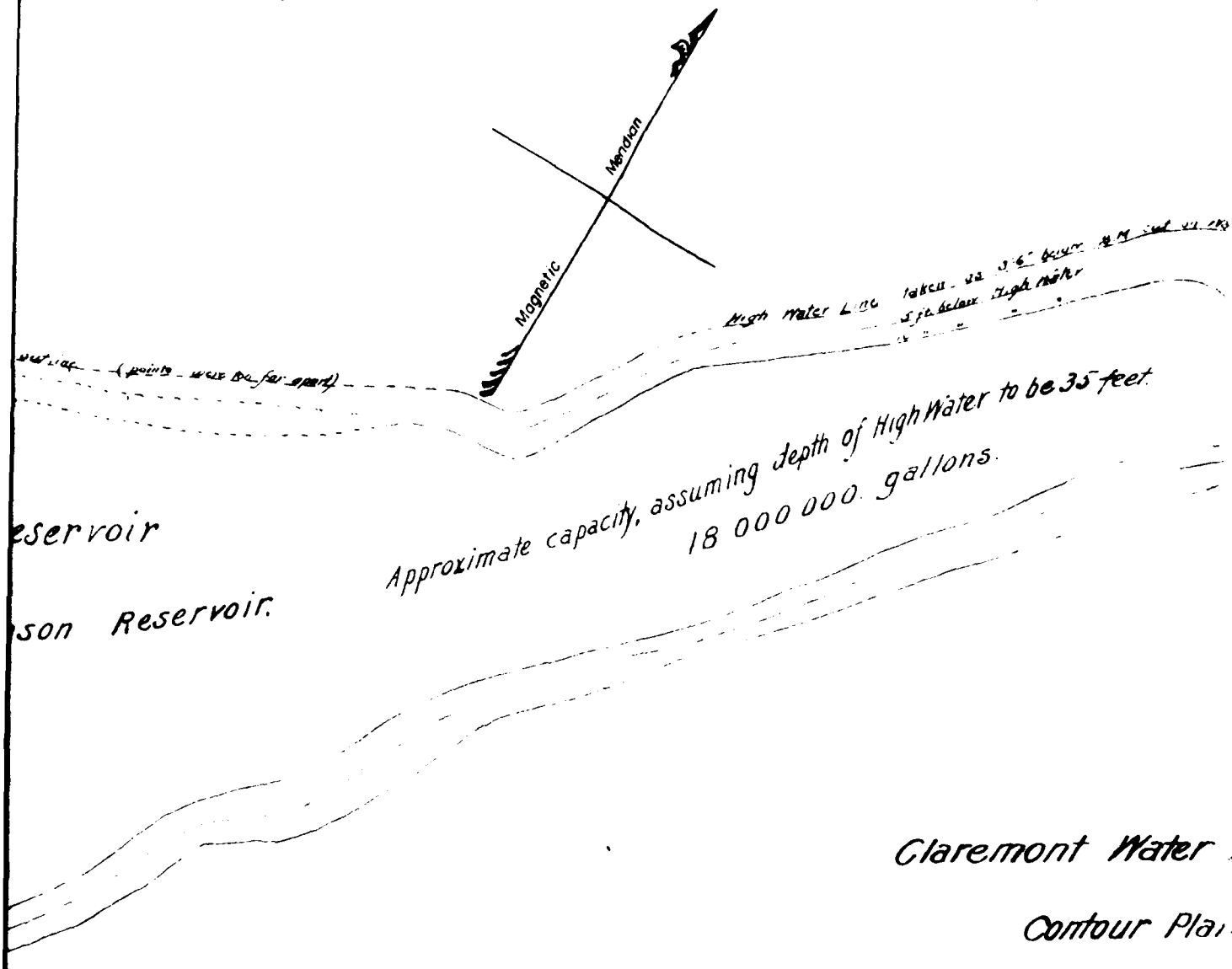
FILE No. 2327

FITCH RESERVOIR DAM NEW HAMPSHIRE

SCALE	1" = 25'
DATE	SEPT 1979







Approximate capacity, assuming depth of High Water to be 35 feet
18 000 000 gallons.

eservoir

son Reservoir.

Claremont Water

Contour Plan

Showing Proposed Loca

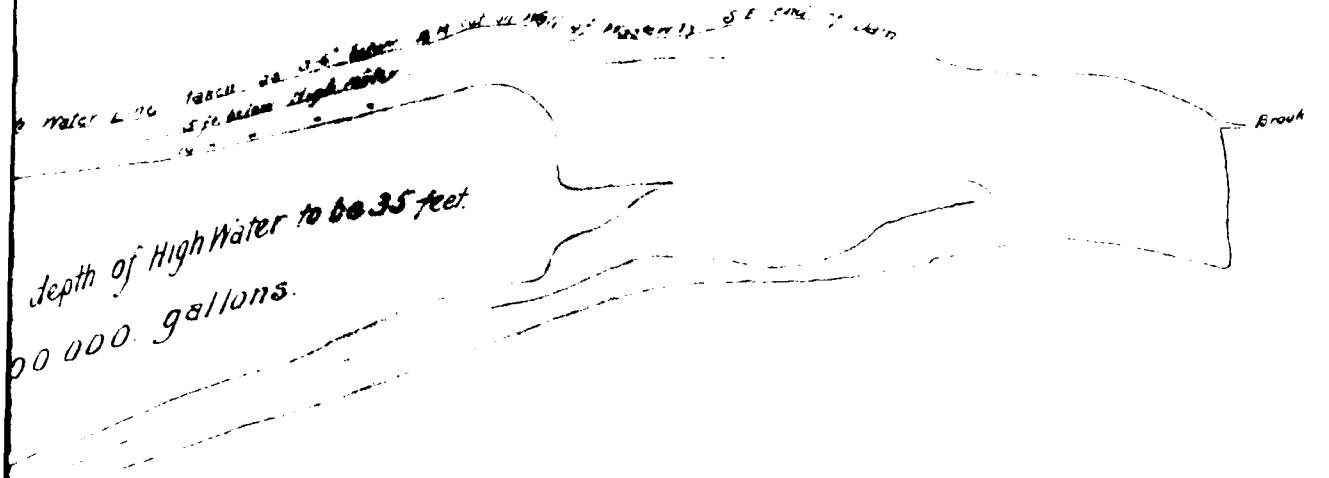
below the

JOHNSON RESE

Claremont

Sept 11, 1899

Geo S Rice & Geo E Evans
Civil & Hydraulic Engineers
93 Milk St Boston Mass



Claremont Water Works Co.

Contour Plan

Showing Proposed Location of Dam

below the

JOHNSON RESERVOIR.

Claremont N. H.

Sept 11, 1899

Scale of Plan, 1 inch = 50 feet.
Scale of Section, 1 inch = 10 feet.

Geo. S. Rice & Son & Emery
Civil & Hydraulic Engineers
93 Mont St Boston Mass

O.N. 967

October 27, 1975

Superintendent
Claremont Water Works
Claremont, New Hampshire 03743

Dear Sir:

On October 20, 1975, an engineer from this office inspected the damage to the embankment at the McQuade Reservoir and leakage at the Fitch Reservoir.

We recommend that the damaged area at McQuade be filled with a granular material that will drain. This should be placed in lifts and properly compacted to reduce the chance of failure and add strength to the embankment. This fill should be covered with loam and seeded to prevent erosion.

Some thought should be given to increasing the discharge capacity of both dams in view of the events of this week. We would recommend that the dam be able to pass a 100 year flood flow without over topping the embankment. Your City Engineer can assist you in this.

If we can be of any further assistance, please call or write.

Very truly yours,

George M. McGee, Sr.
Chairman

GMM/SC3:hb

November 6, 1975

Mr. Louis Sarelas
City Manager
City Hall
Claremont, NH 03743

Dear Sir,

On Nov. 5, 1975 an engineer from this office met with you. Two of the City Council and the head of the water dept. At that time he reviewed the past situation and visited the site of the McQuade and Fitch reserviors. We would recommend that the city increase the discharge capacities of both reserviors. In our opinion the spillway capacity at the Fitch reservior should be increased by drilling and blasting the ledge on the far side of the existing spillway to enlarge the width and thus increasing the capacity of the spillway. If the discharge capacity of the Fitch reservoir is increased then the discharge capacity of the McQuade reservoir should also be increased at least as much as Fitch if not more.

If the city decides to raise the embankment of the McQuade reservior an analyst of the stability of the embankment should be done to insure its safety. The enlargement of the spillway, if this is what you chose to do, should be designed by an engineer to insure its safe operation. No matter what the city plans to do it their choice and these are only suggestions of what you could do.

If you need any further assistance or you have any questions please call or write.

Very truly yours

Mr. George M. McCee Sr.
Chairman

GM/SB/gs

Claremont (Sullivan) Inspected June 30, 1930.

Claremont Water Company

Johnson Reservoir. This is an earth dam built in 1666, with tongue and grooved pine, with puddle clay core wall averaging about 35 to 40 feet in height. Rip rap upstream. Capacity 24,000,000 gallons. The slopes are well grassed. Considerable brush.

DIVI-77.

WATER CONTROL COMMISSION

STATE OF NEW HAMPSHIRE

Concord, New Hampshire

October 13, 1936.

Petition Sent

Claremont Water Works,
Claremont N H

RE: Johnson Bag. Dam. W. C. C. No. 7.13

Gentlemen:

In order that we may determine the magnitude and extent of the flood of September 21-24 just passed, we are requesting the various dam owners in the State to supply us with the following information:

1. Was this dam injured? Ans. Yes

2. If so, to what extent? Ans. About 50 yard of soil on slope

3. Did all flashboards go out? Ans. No

4. What was the maximum height of water over the permanent crest of spillway? Ans. Do not know

5. At what day and hour did the maximum flood height reach your dam? Ans.

6. Any other interesting information regarding the flood or rain fall may be given on the back of this sheet, or attach sheets.

Will you please return this letter with as much information as you can give us as promptly as possible. A self-addressed envelope is attached hereto.

We thank you for your cooperation.

Very truly yours,

Richard S. Holmgren

Richard S. Holmgren
Chief Engineer

CDC:GCB

B-7

NEW HAMPSHIRE WATER CONTROL COMMISSION
DATA ON DAMS IN NEW HAMPSHIRE

LOCATION STATE NO. 7.16

Town Claremont ✓ : County Sullivan

Stream Unnamed

Basin-Primary Conn R ✓ : Secondary Sugar

Local Name Johnson Reservoir

Coordinates—Lat. [illegible] 25' -5820 : Long. 72 [illegible] 01' -5022 ✓

GENERAL DATA 5600

Drainage area: Controlled ..... Sq. Mi.: Uncontrolled ..... Sq. Mi.: Total 1.12 Sq. Mi.

Overall length of dam 210 ✓ ft.: Date of Construction 1892

Height: Stream bed to highest elev. 40 ✓ ft.: Max. Structure 37' ✓ ft.

Cost—Dam ..... : Reservoir .....

DESCRIPTION E- Dam—

Waste Gates

Type .....

Number .....: Size ..... ft. high x ..... ft. wide

Elevation Invert .....: Total Area ..... sq. ft.

Hoist .....

Waste Gates Conduit

Number .....: Materials .....

Size ..... ft.: Length ..... ft.: Area ..... sq. ft.

Embankment

Type .....

Height—Max. ..... ft.: Min. ..... ft.

Top—Width .....: Elev. ..... ft.

Slopes—Upstream ..... on .....: Downstream ..... on .....

Length—Right of Spillway .....: Left of Spillway .....

Spillway

Materials of Construction .....

Length—Total ..... ft.: Net 101' ✓ ft.

Height of permanent section—max. 37' ✓ ft.: Min. ..... ft.

Flashboards—Type .....: Height ..... ft.

Elevation—Permanent Crest .....: Top of Flashboard .....

Flood Capacity ..... cfs.: ..... cfs/sq. mi.

Abutments

Materials: .....

Freeboard: Max. 3.0' ✓ ft.: Min. ..... ft.

Headworks to Power Devel.—(See "Data on Power Development")

OWNER Town of Claremont

REMARKS Water Supply (2 Acres Acres)

Tabulation By [illegible] Date [illegible]

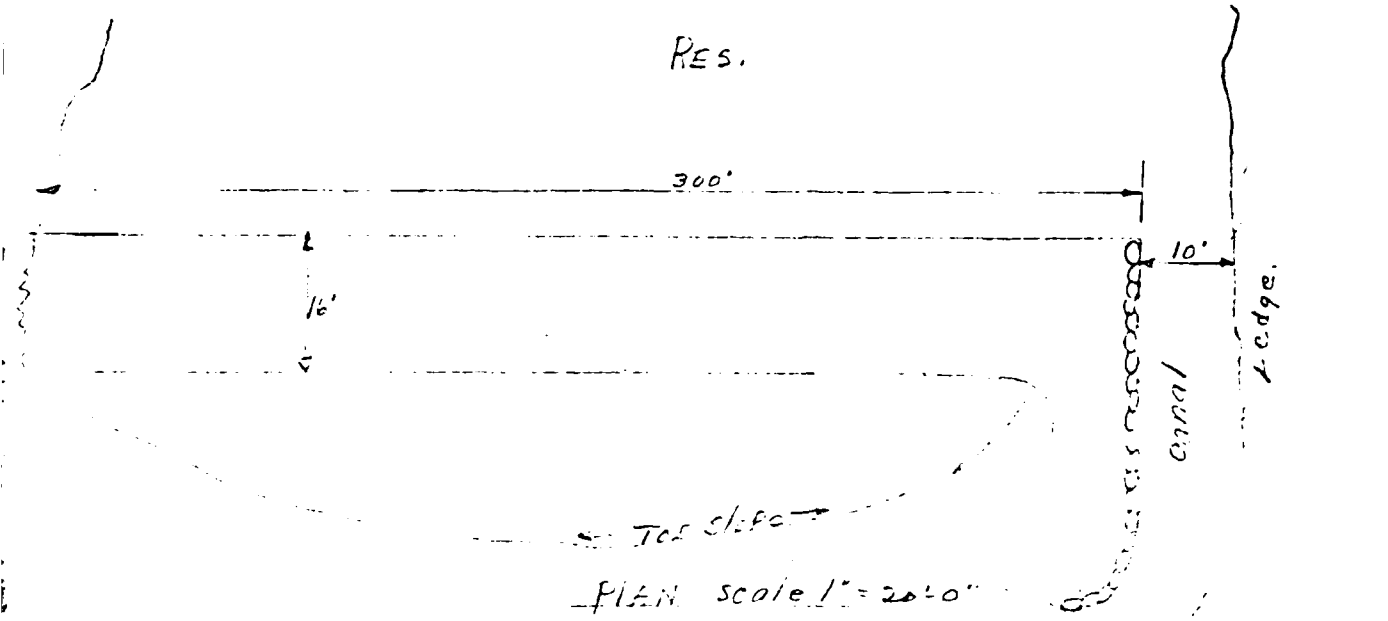
AMPSHIRE RESOURCES DARD DRD. N. H.

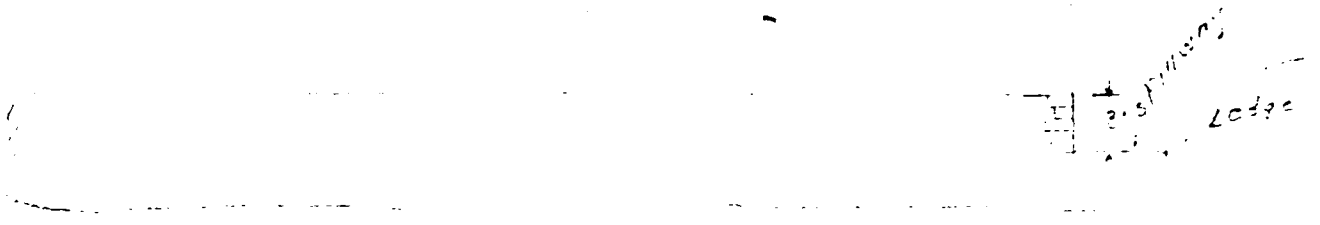
PROJECT FILE 47.16

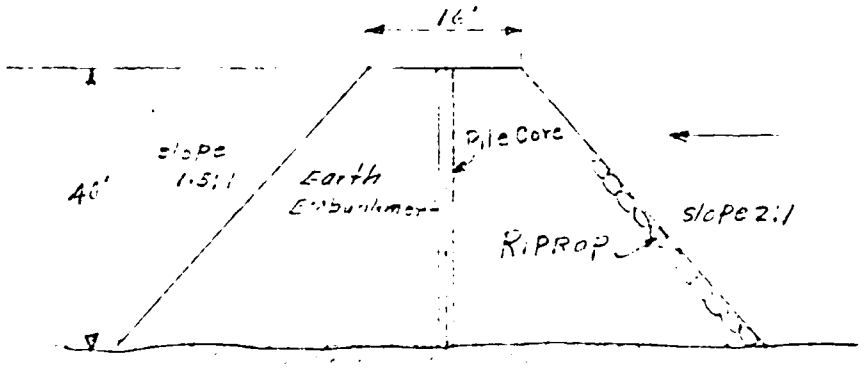
SUBJECT JOHNSONS RESERVOIR CLAREMONT ACC

CONN. R. SUGAR R. TOWN of CLAREMONT

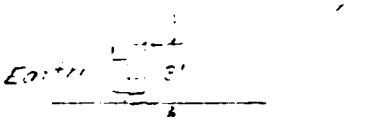
COMPUTER G.S.W CHECKER PL CONT. FROM ACC CONT. ON ACC SUMMARY ON ACC DATE 9/24/73







X-section



NEW HAMPSHIRE WATER RESOURCES BOARD

INVENTORY OF DAMS AND WATER POWER DEVELOPMENTS

DAM

BASIN *Connecticut* NO. *16* *47.16*
RIVER *Johnson Reservoir* MILES FROM MOUTH ____ D.A.SQ.MI *0.2±*
TOWN *Claremont* OWNER *Claremont Water Works*
LOCAL NAME OF DAM
BUILT *1894* DESCRIPTION *Earth + Stone* *2 blank ...*

POND AREA-ACRES *3±* DRAWDOWN FT. *35* POND CAPACITY-ACRE FT. *73.6*
HEIGHT-TOP TO BED OF STREAM-FT. *40* MAX. MIN.
OVERALL LENGTH OF DAM-FT. *310* MAX.FLOOD HEIGHT ABOVE CREST-FT.
PERMANENT CREST ELEV.U.S.G.S. LOCAL GAGE
TAILWATER ELEV.U.S.G.S. LOCAL GAGE
SPILLWAY LENGTHS-FT. *10* FREEBOARD-FT. *5.0 ±*
FLASHBOARDS-TYPE,HEIGHT ABOVE CREST *1.0*
WASTE GATES-NO. WIDTH MAX.OPENING DEPTH SILL BELOW CREST

REMARKS *Condition Good 2H. On Branch Grandy Bk. Into Phelps Reservoir, Straw Reservoir, City mains. overflow into Grandy Bk, Sugar R. Water from this reservoir flows into Phelps Reservoir controlled by valve on down stream face of this dam.*

POWER DEVELOPMENT

UNITS NO.	RATED HP	HEAD FEET	C.F.S. FULL GATE	KW	MAKE

USE *Water Supply*

REMARKS *Information from Supt Claremont Water Works 6/15/37 Says dam 320' long spillway 10' long carried 50 ft. from dam capacity 24500000 gal. flash board adds 1,500,000 Geo. S. Rice & Geo E Evans 95 Milk St. Boston designers Shown by Chas. Easter, Supt.*

Tracing says 18 000 000 gal. cap.

DATE *1935*

10/1/37 R+J. H.S. B-10

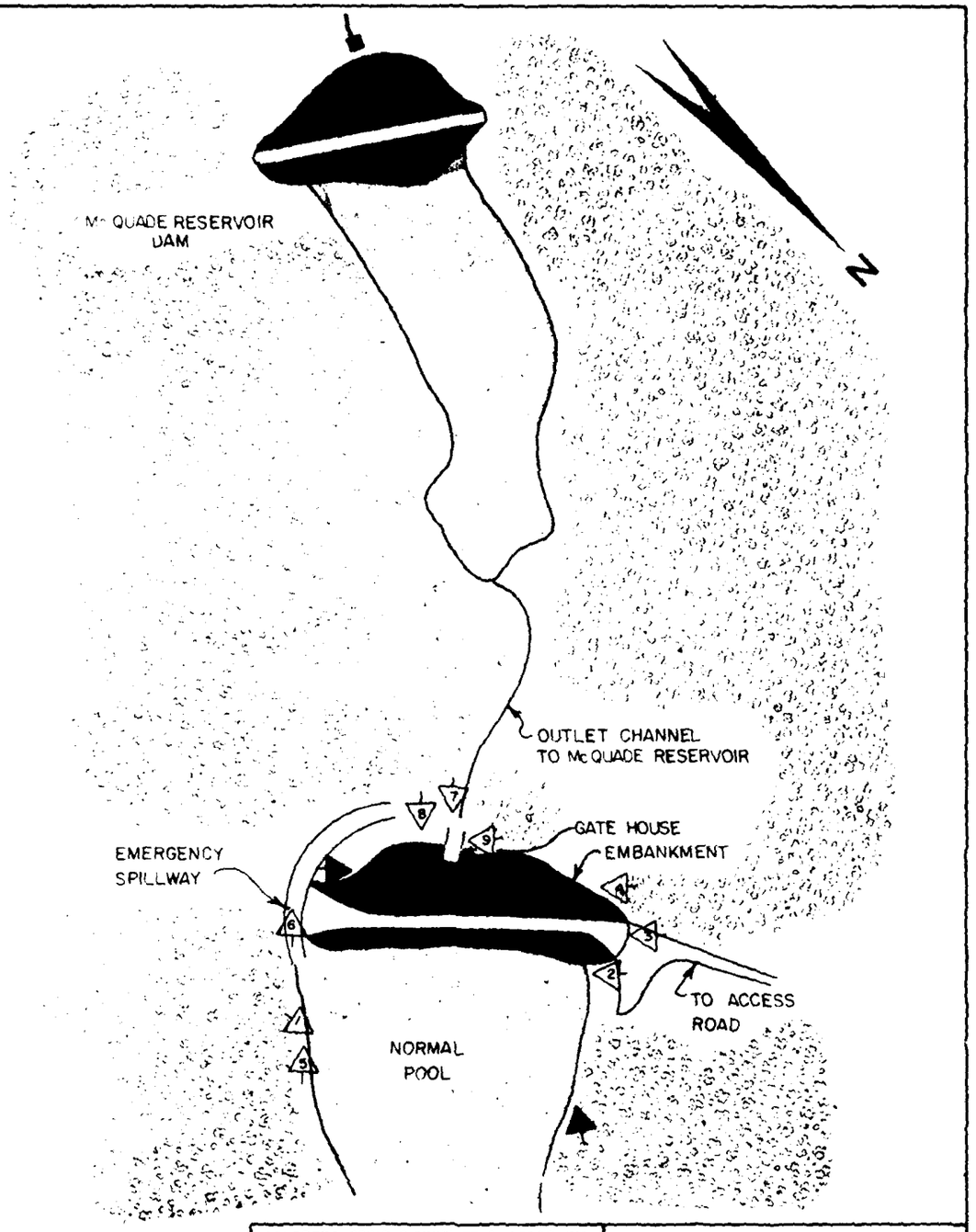
Pertinent Data Not Included

The New Hampshire Water Resources Board maintains a file on this dam including most of the material in this appendix, plus copies of newspaper articles relating to the dam.

The Claremont Water Department maintains an intermittent record of reservoir stage based on visual observations.

APPENDIX C

PHOTOGRAPHS



GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

OVERVIEW PHOTOS

APPENDIX C PHOTOS

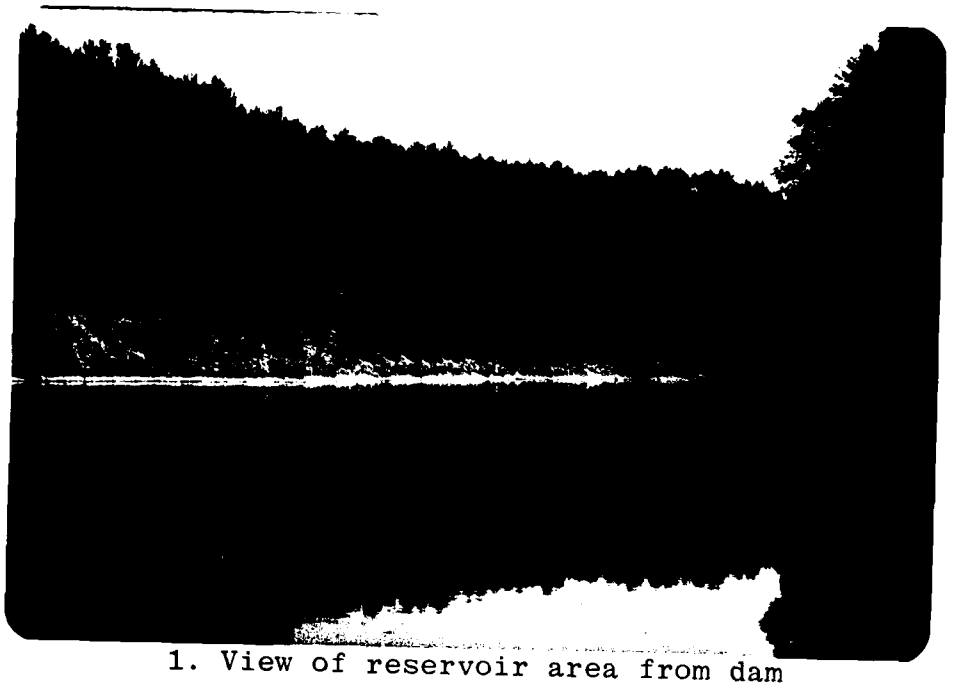
LOCATION AND ORIENTATION OF PHOTOS

FILE No. 2327

FITCH RESERVOIR DAM NEW HAMPSHIRE

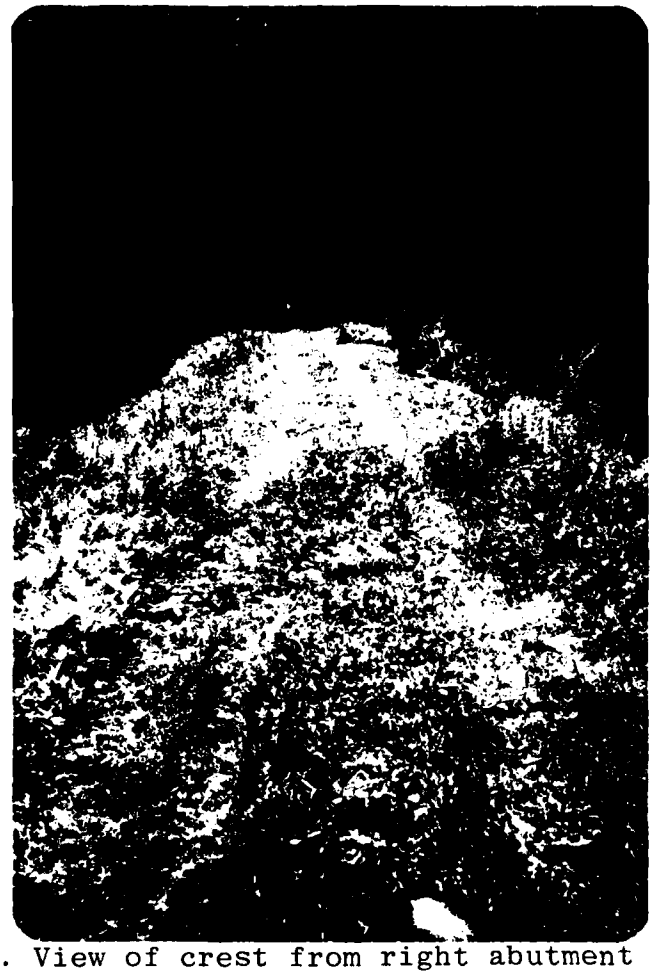
SCALE 1" = 25'

DATE SEPT 1979

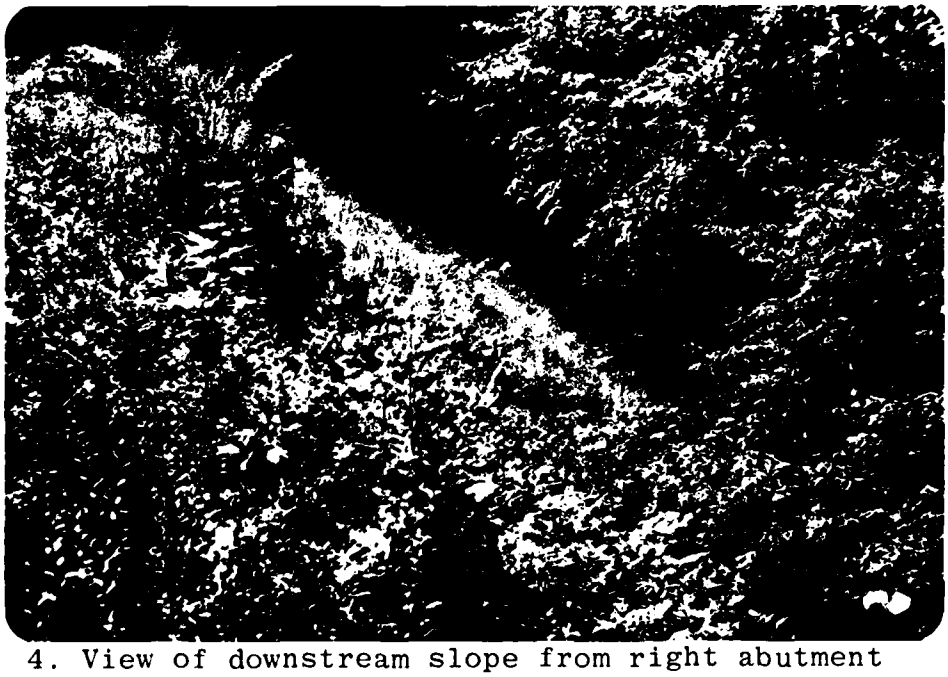


1. View of reservoir area from dam

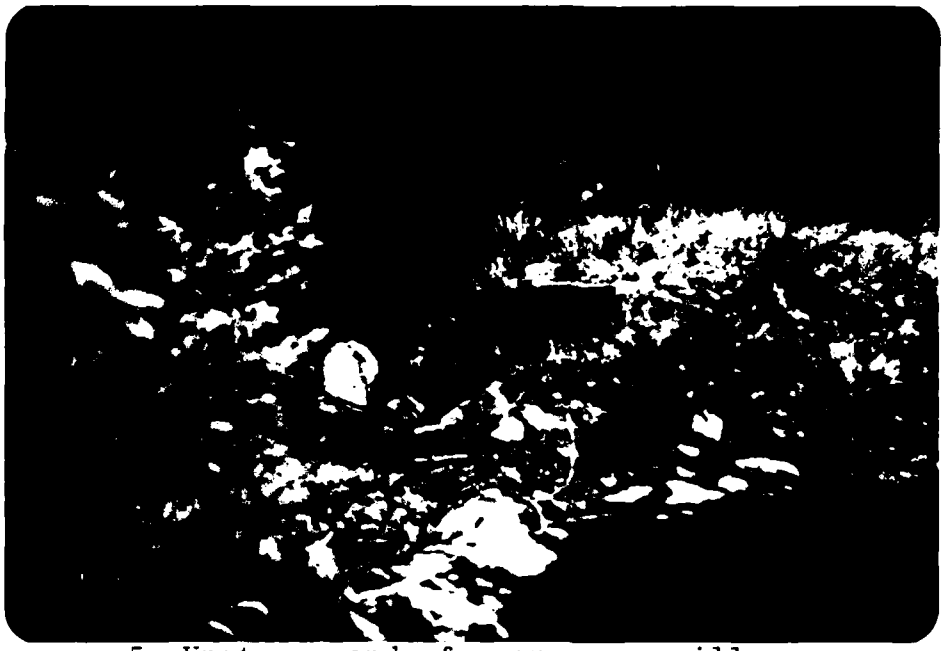
2. View of upstream slope showing riprap



3. View of crest from right abutment



4. View of downstream slope from right abutment



5. Upstream end of emergency spillway

6. Emergency spillway channel looking downstream. Note rock from end wall in channel

7. Downstream end of 24 inch diameter outlet pipe. Note siltation to springline

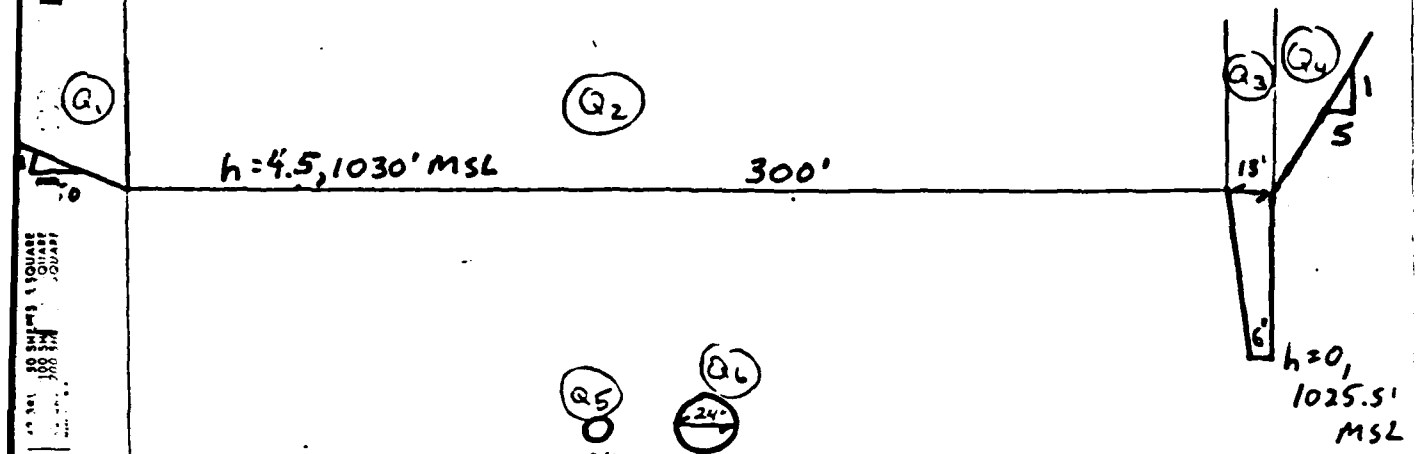
8. Overgrown downstream end of 8 inch diameter outlet pipe

9. Interior of gate house

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

The information used to establish this elevation of Fitch Reservoir Dam was determined from field notes.



invert elevations unknown. Outlets to both at ~ h: -35' 990' MSL ±

The 2 pipes (8" CIP - water supply outlet and 24" - pond drain outlet) are controlled by gate valves operated from a gate house on the downstream side of the dam. Since these valves are usually closed and there are no plans to open them in the event of a storm, they will be assumed to be closed for these calculations. (As an estimate - assuming a head of 35 ft for each pipe, orifice control at the inlets yields:

$Q_{5max} = .611\,(\pi(1/3)^2)\sqrt{2g\,35} \cong 10$ cfs

$Q_{6max} = .611\,(\pi(1)^2)\sqrt{2g\,35} \cong 90$ cfs. 100 cfs total if both pipes are open).

Stage - Discharge Curve

$h < 0$

$Q_1 = Q_2 = Q_3 = Q_4 = Q_5^* = Q_6^* = 0$

$0 < h < 4.5$

Q_3 = spillway flow = flow over 6 ft. b.c. weir + flow over side slope

$= 3.0 \cdot 6 \cdot h^{3/2} + 2.8 \cdot \left(h\left(\frac{13-6}{4.5}\right)\right)\left(\frac{1}{2}h\right)^{3/2}$

all others unchanged

3.0 = B.C. rock weir
2.8 = B.C. dirt weir or overgrown rock weir

$h > 4.5$

$Q_1 = 2.8 \cdot 50 (h - 4.5) \left(\frac{1}{2}(h - 4.5)\right)^{3/2}$

$Q_2 = 2.8 \cdot 300 \cdot (h - 4.5)^{3/2}$

$Q_4 = 2.8 \cdot 5 (h - 4.5) \left(\frac{1}{2}(h - 4.5)\right)^{3/2}$

The BASIC program given on pp. 3-5 calculates the Stage-Discharge relationship for the dam.

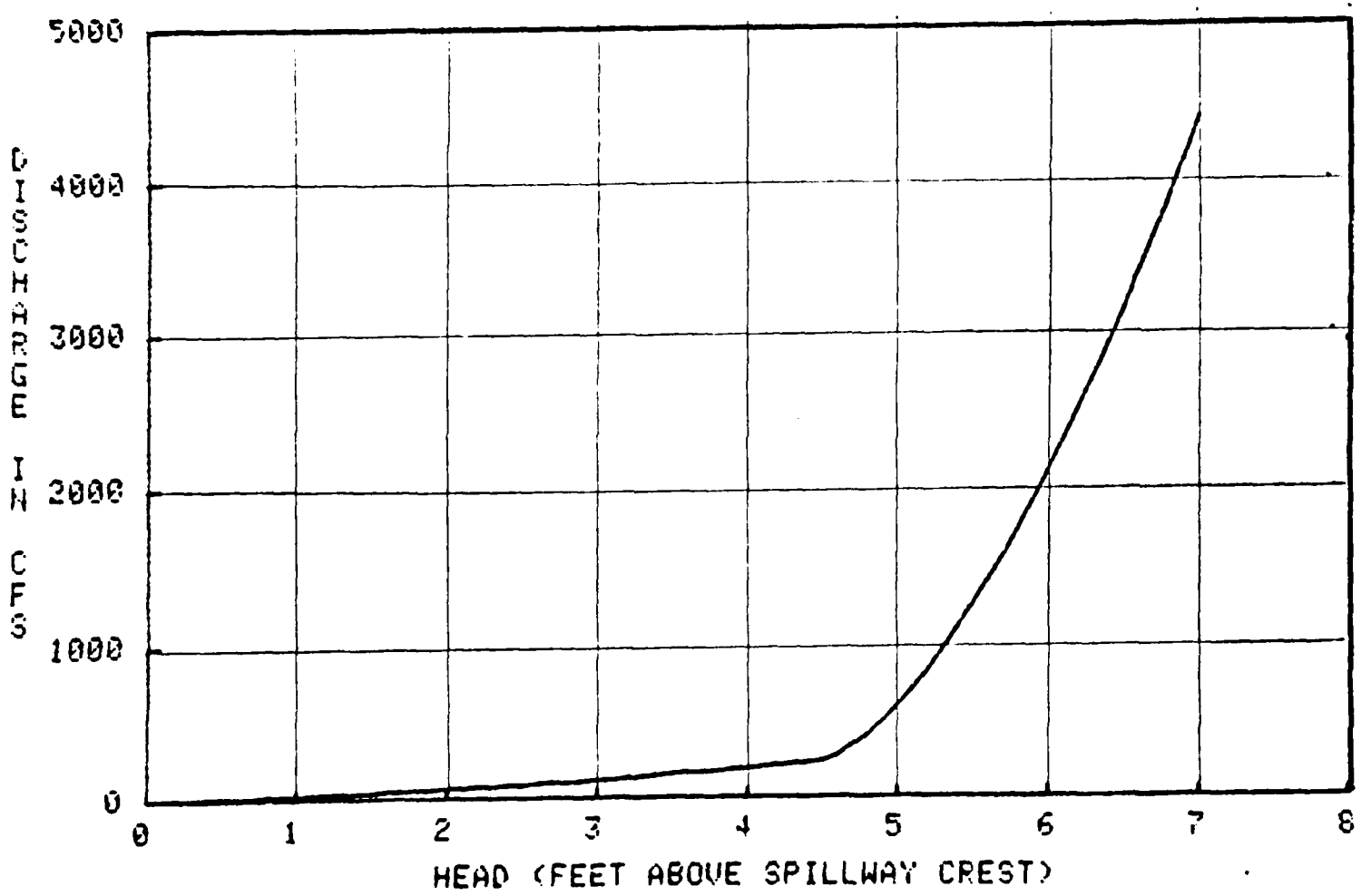
* both gates assumed closed

```
LIST
100 REM - STAGE/DISCHARGE CURVE FOR  Fitch RESERVOIR DAM
110 REM - STORED ON TAPE B-1 FILE 5
120 PAGE
130 PRINT USING 140:
140 IMAGE 10T"STAGE-DISCHARGE RELATIONSHIP FOR Fitch RESERVOIR DAM"
150 PRINT USING 160:
160 IMAGE //10T"HEAD"                45T"DISCHARGE"
170 PRINT USING 180:
180 IMAGE 1T"(FEET ABOVE S/W CREST)"47T"(CFS)"
190 PRINT USING 200:
200 IMAGE 30T "TOTAL          SPILLWAY          TOP OF DAM"
205 PRINT " "
210 FOR H=0 TO 7 STEP 0.25
220 Q1=0
230 Q2=0
240 Q3=0
250 Q4=0
260 Q3=3*5*H↑1.5+2.8*(H*(7/4.5))*(0.5*H)↑1.5
270 IF H<4.5 THEN 310
280 Q1=2.8*(50*(H-4.5))*(0.5*(H-4.5))↑1.5
290 Q2=2.8*300*(H-4.5)↑1.5
300 Q4=2.8*(5*(H-4.5))*(0.5*(H-4.5))↑1.5
310 T1=Q1+Q2+Q3+Q4
320 T2=T1-Q3
330 PRINT USING 340:H,T1,Q3,T2
340 IMAGE 9BT,3D.2D,21D,18D,19D
350 NEXT H
360 END
```

STAGE/DISCHARGE RELATIONSHIP FOR Fitch RESERVOIR DAM

HEAD (FEET ABOVE S/W CREST)	DISCHARGE (CFS) TOTAL	SPILLWAY	TOP OF DAM
0.00	0	0	0
0.25	[illegible]	[illegible]	0
0.50	[illegible]	[illegible]	0
0.75	12	12	0
1.00	[illegible]	[illegible]	0
1.25	[illegible]	[illegible]	0
1.50	[illegible]	[illegible]	0
1.75	48	48	0
2.00	[illegible]	60	0
2.25	[illegible]	[illegible]	0
2.50	[illegible]	[illegible]	0
2.75	101	101	0
3.00	118	118	0
3.25	[illegible]	135	0
3.50	[illegible]	153	0
3.75	[illegible]	172	0
4.00	193	193	0
4.25	215	215	0
4.50	[illegible]	239	0
4.75	[illegible]	262	10[illegible]
5.00	594	287	30[illegible]
5.25	[illegible]	314	5[illegible]2
5.50	1236	341	894
5.75	1639	370	1269
6.00	2094	400	1693
6.25	2597	432	2165
6.50	3148	464	2684
6.75	3746	498	3248

STAGE/DISCHARGE CURVE FOR Fitch RESERVOIR DAM



Stage - Storage Curve

Assuming a pond area of 3 acres and no spreading as the pond rises, surcharge storage is given by:

$S = 3(4)$

Total storage = 74 + 34

The storage vs. stage curve is given on p. 7

For the drainage area of 520 acres:

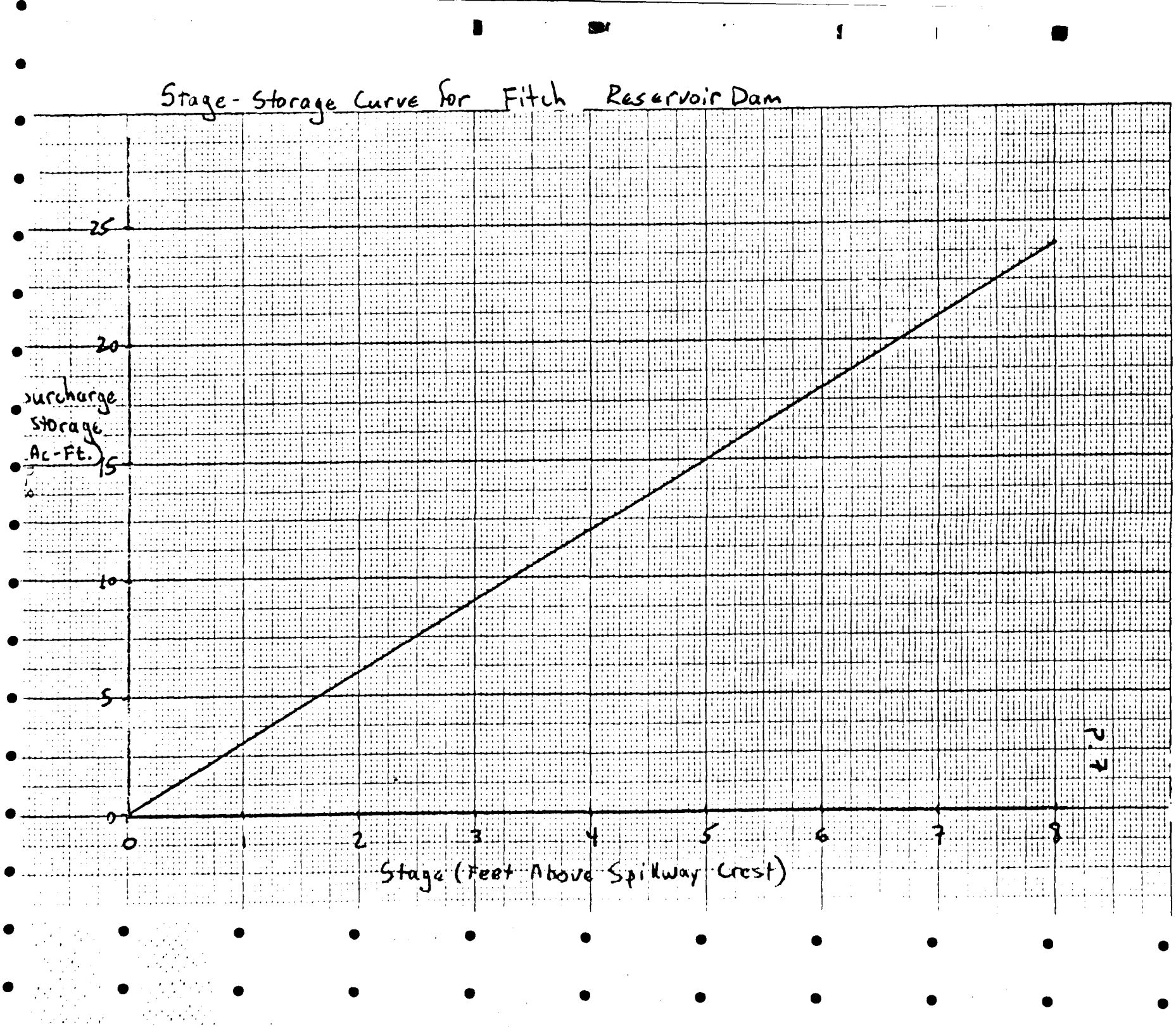
1" of runoff = 1/12 (520) = 43 ac-ft.

1 Ac-ft: $\frac{1}{43}$ = .023" of runoff

Surcharge storage to top of dam = 3(4.5) = 13.5 AC Ft

13.5 (.023) = .31" of runoff.

total storage = 74 + 13.5 = 87.5 AF


Stage - Storage Curve for Fitch Reservoir Dam
Surcharge Storage Ac-Ft.
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
Stage (Feet Above Spillway Crest)
P.2

Dam Failure Analysis

A location and downstream hazard map for Fitch Reservoir Dam is given at the end of this appendix.

Assume failure occurs when the water surface elevation reaches the top of the dam.

The pre-failure flow is 238 cfs, and the storage is $74 + 3(4.5) = 87.5$ Ac-ft.

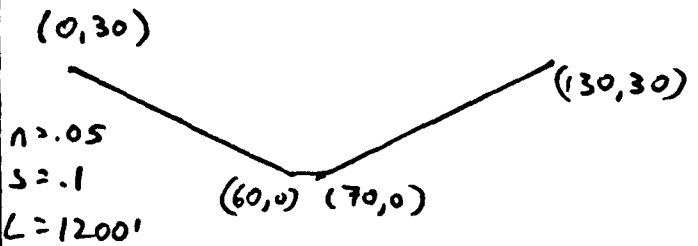
Peak Dam Failure outflow = Normal Outflow + Breach Outflow

Normal outflow = 238 cfs

Breach outflow = $Q_{p_1} = 8/27 \sqrt{g}\, W_b\, y_o^{3/2}$

where: W_b = breach width = 40% of width at 1/2 ht of dam. = .4(200 ±) = 80'. (Width estimated from 1899 contour map by Rice & Evans). Y_o = height above tailwater at time of failure.

Tailwater is controlled by the stream downstream of the reservoir. The following cross-section is typical for the 1200 ft. reach of Grandy Bk. from Fitch Reservoir to McQuade Reservoir (based on field notes and USGS Topo.):



A Depth-Normal flow relationship for this reach is given on p. 9. The pre-failure outflow of 238 cfs would cause 2 feet of flow

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.00	0.0	0.0	0.0	0.0	0.0	0.0
1.00	1.0	12.0	14.5	0.8	10.6	99.8
2.00	2.0	28.0	18.9	1.5	36.3	342.4
3.00	3.0	48.0	23.4	2.0	77.5	730.1
4.00	4.0	72.0	27.9	2.6	135.5	1277.3
5.00	5.0	100.0	32.4	3.1	212.2	2000.0
6.00	6.0	132.0	36.8	3.6	309.3	2914.3
7.00	7.0	168.0	41.3	4.1	428.3	4035.8
8.00	8.0	208.0	45.8	4.5	570.9	5379.9
9.00	9.0	252.0	50.2	5.0	738.7	6961.4
10.00	10.0	300.0	54.7	5.5	933.3	8794.8
11.00	11.0	352.0	59.2	5.9	1156.1	10894.2
12.00	12.0	408.0	63.7	6.4	1408.5	13273.4
13.00	13.0	468.0	68.1	6.9	1692.1	15945.8
14.00	14.0	532.0	72.6	7.3	2008.2	18924.6
15.00	15.0	600.0	77.1	7.8	2358.2	22222.7
16.00	16.0	672.0	81.6	8.2	2743.4	25852.7
17.00	17.0	748.0	86.0	8.7	3165.2	29827.1
18.00	18.0	828.0	90.5	9.1	3624.7	34158.1
19.00	19.0	912.0	95.0	9.6	4123.4	38857.6
20.00	20.0	1000.0	99.4	10.1	4662.5	43937.5
21.00	21.0	1092.0	103.9	10.5	5243.2	49409.4
22.00	22.0	1188.0	108.4	11.0	5866.6	55284.8
23.00	23.0	1288.0	112.9	11.4	6534.1	61574.9
24.00	24.0	1392.0	117.3	11.9	7246.8	68291.1
25.00	25.0	1500.0	121.8	12.3	8005.9	75444.1
26.00	26.0	1612.0	126.3	12.8	8812.5	83045.1
27.00	27.0	1728.0	130.7	13.2	9667.7	91104.6
28.00	28.0	1848.0	135.2	13.7	10572.6	99633.3
29.00	29.0	1972.0	139.7	14.1	11528.7	108641.8
30.00	30.0	2100.0	144.2	14.6	12536.7	118140.3

DEPTH VS. NORMAL FLOW FOR REACH FROM Fitch RES. DAM TO MCQUADE RES.

P.4

in the channel downstream of the dam.

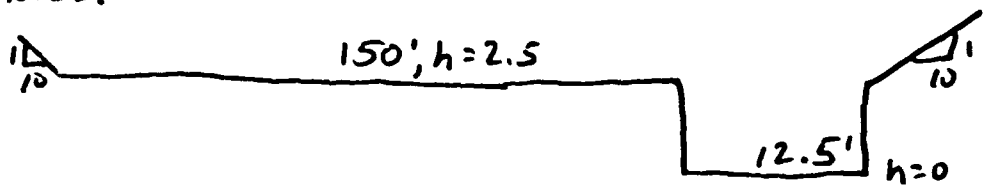
Therefore, $y_o \cong 40 - 2 = 38'$

$$Q_{p_1} = \frac{8}{27}\sqrt{g}\,(80)(38)^{3/2} = 31,500 \text{ cfs}$$

Peak failure outflow = 31,500+200 = 31,700 cfs.

There is no significant development on the reach from Fitch Reservoir Dam to McQuade Reservoir. The attenuation to peak dam failure outflow due to storage in this reach is calculated on p. 11. The attenuated peak dam failure flow into McQuade Reservoir Dam would be 25,400 cfs, which would create a stage of 15.9 ft. in the Grandy Bk. channel.

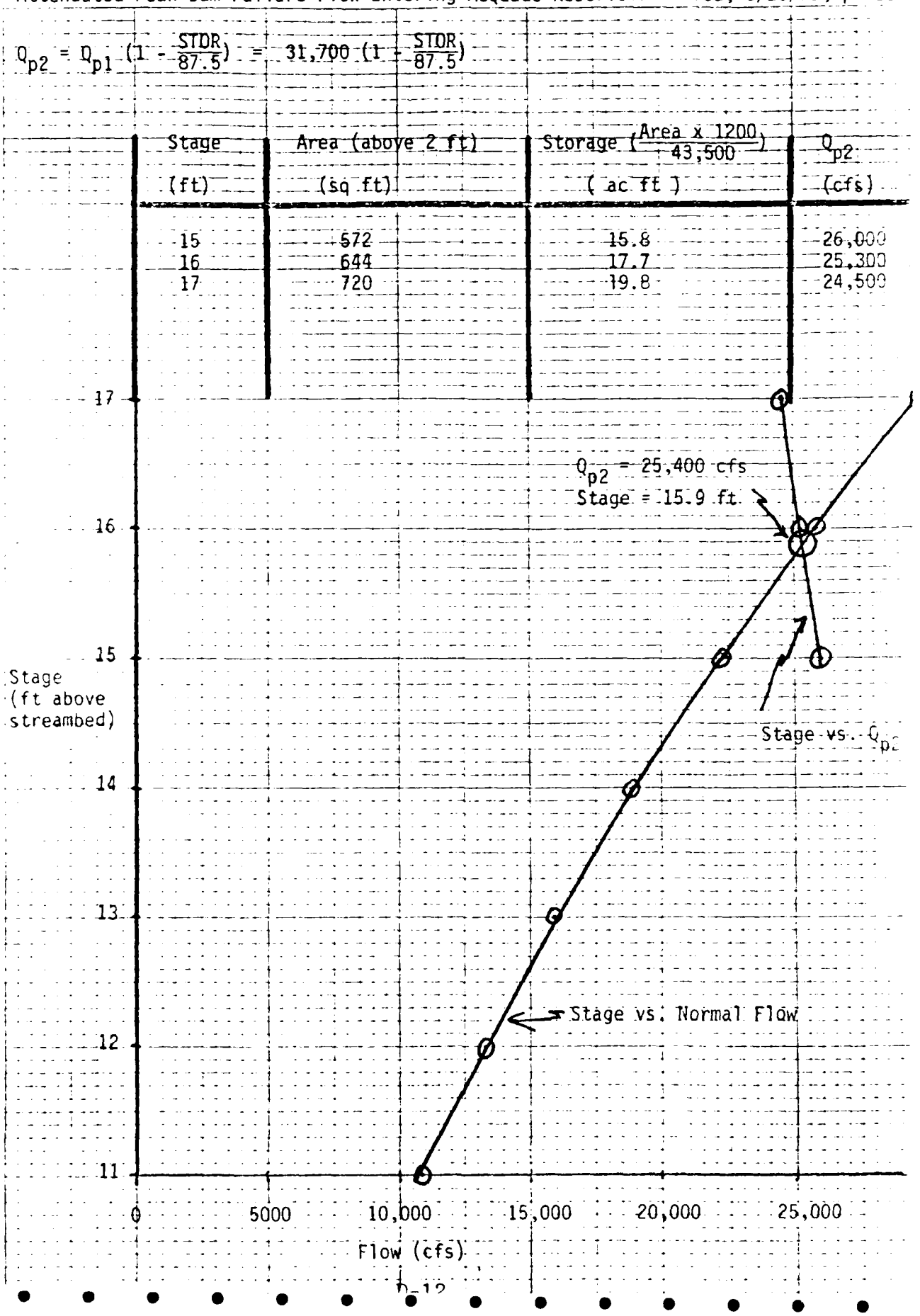
McQuade Reservoir Dam is an earth fill structure. The following elevation of the dam is based on field notes.



A stage-Discharge Curve for this dam is given on p. 12. The surcharge storage behind McQuade Reservoir Dam is estimated as 1 (h). The attenuated Peak Dam Failure Outflow over McQuade Reservoir Dam is calculated on p. 14. The attenuated peak dam failure flow of 22,500 cfs would create

$$Q_{p2} = Q_{p1}\left(1 - \frac{STOR}{87.5}\right) = 31{,}700\left(1 - \frac{STOR}{87.5}\right)$$

Stage (ft)	Area (above 2 ft) (sq ft)	Storage $\left(\frac{\text{Area} \times 1200}{43{,}500}\right)$ (ac ft)	Q_{p2} (cfs)
15	572	15.8	26,000
16	644	17.7	25,300
17	720	19.8	24,500



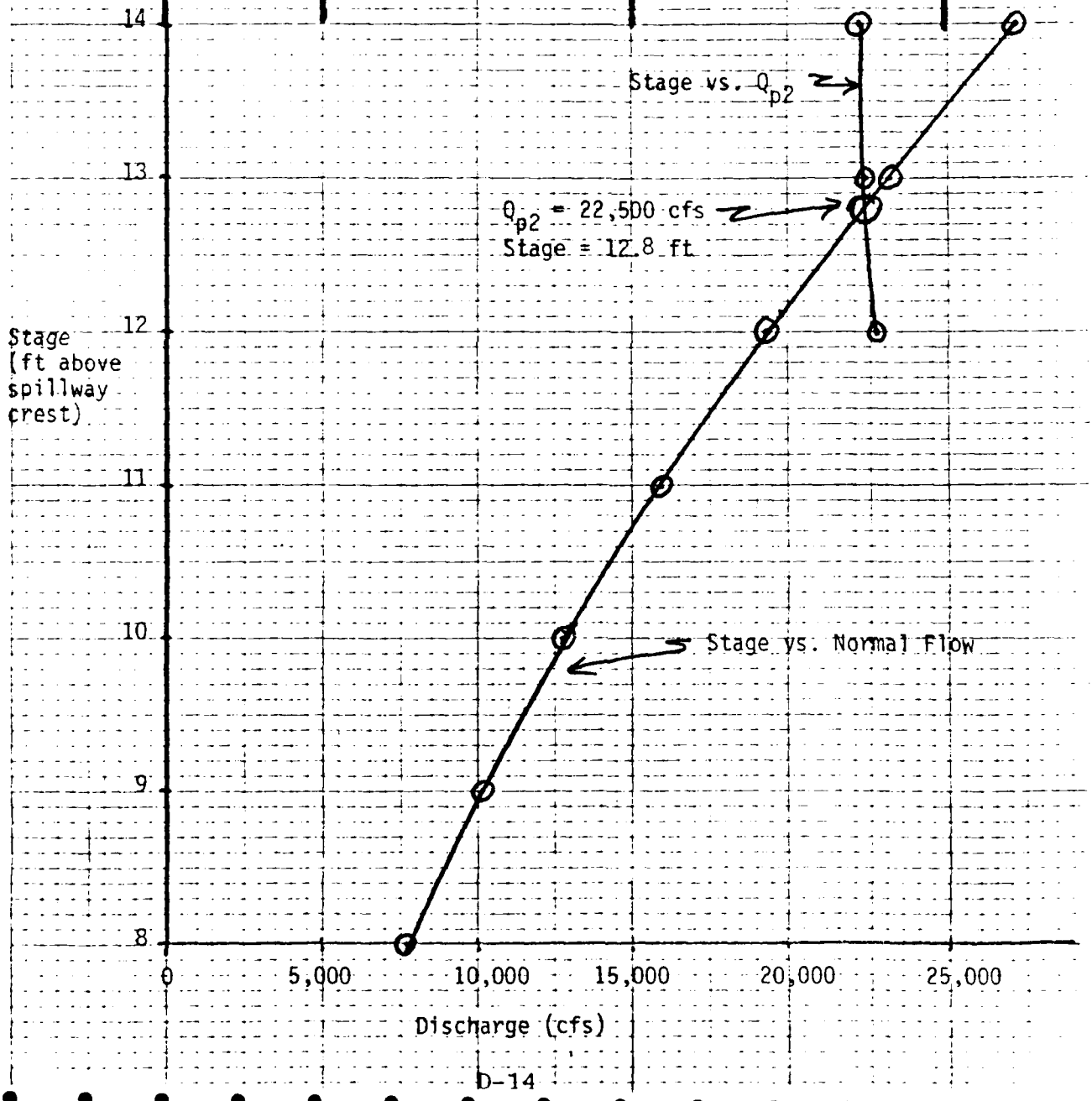
STAGE/DISCHARGE RELATIONSHIP FOR MCQUADE RESERVOIR DAM

HEAD (FEET ABOVE S/W CREST)	DISCHARGE (CFS) TOTAL	SPILLWAY	TOP OF DAM
0.00	0	0	0
1.00	38	38	0
2.00	106	106	0
3.00	347	195	152
4.00	1126	300	826
5.00	2275	419	1856
6.00	3755	551	3204
7.00	5554	695	4860
8.00	7671	849	6822
9.00	10105	1013	9093
10.00	12856	1186	11677
11.00	15947	1368	14579
12.00	19364	1559	17805
13.00	23121	1758	21363
14.00	27223	1964	25259
15.00	31673	2179	29499
15.00	36491	2400	34091
17.00	41670	2629	39041
18.00	47221	2864	44357
19.00	53151	3106	50045
20.00	59467	3354	56112

P.12

$$Q_{p2} = Q_{p1}\left(1 - \frac{STOR}{87.5}\right) = 25{,}400\left(1 - \frac{STOR}{87.5}\right)$$

Stage (ft above spillway crest)	Storage (above 2.5 ft) (ac ft)	Q_{p2} (cfs)
12	9.5	22,600
13	10.5	22,350
14	11.5	22,100

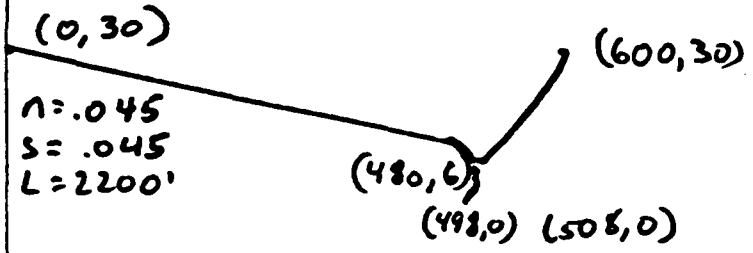


a stage 10.4ft. over the dam crest at McQuade Reservoir Dam. This would probably cause severe damage to McQuade Reservoir Dam, which is a source of water for the town of Claremont. (The dam might well fail, but failure would not add significantly to the failure outflow from Johnson Reservoir Dam.) Before the failure of Fitch Reservoir Dam, McQuade Reservoir Dam would be slightly overtopped.

Downstream of McQuade Reservoir, Grandy Brook runs about 2200 feet to a road crossing. Near the upstream end of this reach there is a large house 12-13 feet above the streambed. (400 ft. from McQuade Res. Dam.) About 500 ft. from McQuade Res. Dam, Grandy Brook is crossed by a dirt road on a 7 foot embankment with a 48" cmp culvert. At dam failure flows this embankment would not attenuate flows significantly, and its effect is ignored. Just downstrea of this road crossing there is a house about 8 ft. above the streambed. There are 4 more houses in this reach. 3 are on the brooks east bank, and are well (25+ ft) above the streambed. The fourth is just upstream of the road crossing and is 22 feet above the streambed. This structure might be threatened by backwater from the road crossing.

The following cross-section is typical for the reach from McQuade Res. Dam to Road Crossing #1 (based on field

notes and USGS top.):



A Depth-Normal Flow relationship for this reach is given on p. 17. The pre-failure flow of 240 cfs would cause about 2 feet of flow in this reach. The attenuation due to storage in the reach is calculated on p. 18.

The attenuated peak failure outflow of 13,500 cfs would create a stage of 11.2 ft at the downstream end of this reach. The two houses threatened by dam failure are about 25% of the way down this reach. Assuming 25% of the attenuation occurs before these houses are reached:

$Q = 22{,}500 - .25(22500-13500) \doteq 20{,}000$ cfs,

which gives a stage of 12.6 ft. at this location. This would threaten minor flooding in the house 12-13 feet above the stream, and create serious flooding (4-5 ft.) in the house about 8 feet up. There would be a threat to life at this location.

The downstream end of this reach is the first road crossing - a residential street in Claremont. The following cross-section is based on field notes.

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.00	0.0	0.0	0.0	0.0	0.0	0.0
1.00	1.0	13.0	16.4	0.8	11.2	78.6
2.00	2.0	32.1	22.9	1.4	40.4	283.9
3.00	3.0	57.3	29.2	2.0	89.9	631.5
4.00	4.0	89.5	35.6	2.5	162.7	1142.8
5.00	5.0	125.8	41.9	3.0	261.9	1839.3
6.00	6.0	169.2	48.3	3.5	390.3	2741.4
7.00	7.0	227.1	71.6	3.2	490.7	3446.4
8.00	8.0	308.1	94.8	3.2	676.3	4758.0
9.00	9.0	412.2	118.1	3.5	949.0	6665.4
10.00	10.0	539.3	141.3	3.8	1317.7	9255.1
11.00	11.0	689.5	164.6	4.2	1792.9	12593.0
12.00	12.0	862.8	187.9	4.6	2385.4	16754.8
13.00	13.0	1059.1	211.1	5.0	3105.9	21815.5
14.00	14.0	1278.5	234.3	5.5	3954.7	27847.8
15.00	15.0	1521.0	257.6	5.9	4972.0	34922.7
16.00	16.0	1786.5	280.9	6.4	6137.4	43109.0
17.00	17.0	2075.1	304.1	6.8	7470.7	52473.4
18.00	18.0	2386.8	327.3	7.3	8990.9	63081.2
19.00	19.0	2721.5	350.6	7.8	10677.2	74995.9
20.00	20.0	3079.3	373.8	9.2	12568.4	88279.4
21.00	21.0	3460.2	397.1	8.7	14663.1	102992.5
22.00	22.0	3864.1	420.3	9.2	16969.9	119194.6
23.00	23.0	4291.1	443.6	9.7	19496.8	136943.9
24.00	24.0	4741.2	466.8	10.2	22252.2	156297.5
25.00	25.0	5214.3	490.1	10.6	25244.0	177311.7
26.00	26.0	5710.5	513.3	11.1	28480.0	200041.7
27.00	27.0	6229.8	536.6	11.6	31968.1	224541.8
28.00	28.0	6772.1	559.8	12.1	35715.8	250865.4
29.00	29.0	7337.5	583.1	12.6	39730.7	279065.5
30.00	30.0	7926.0	606.3	13.1	44020.1	309193.9

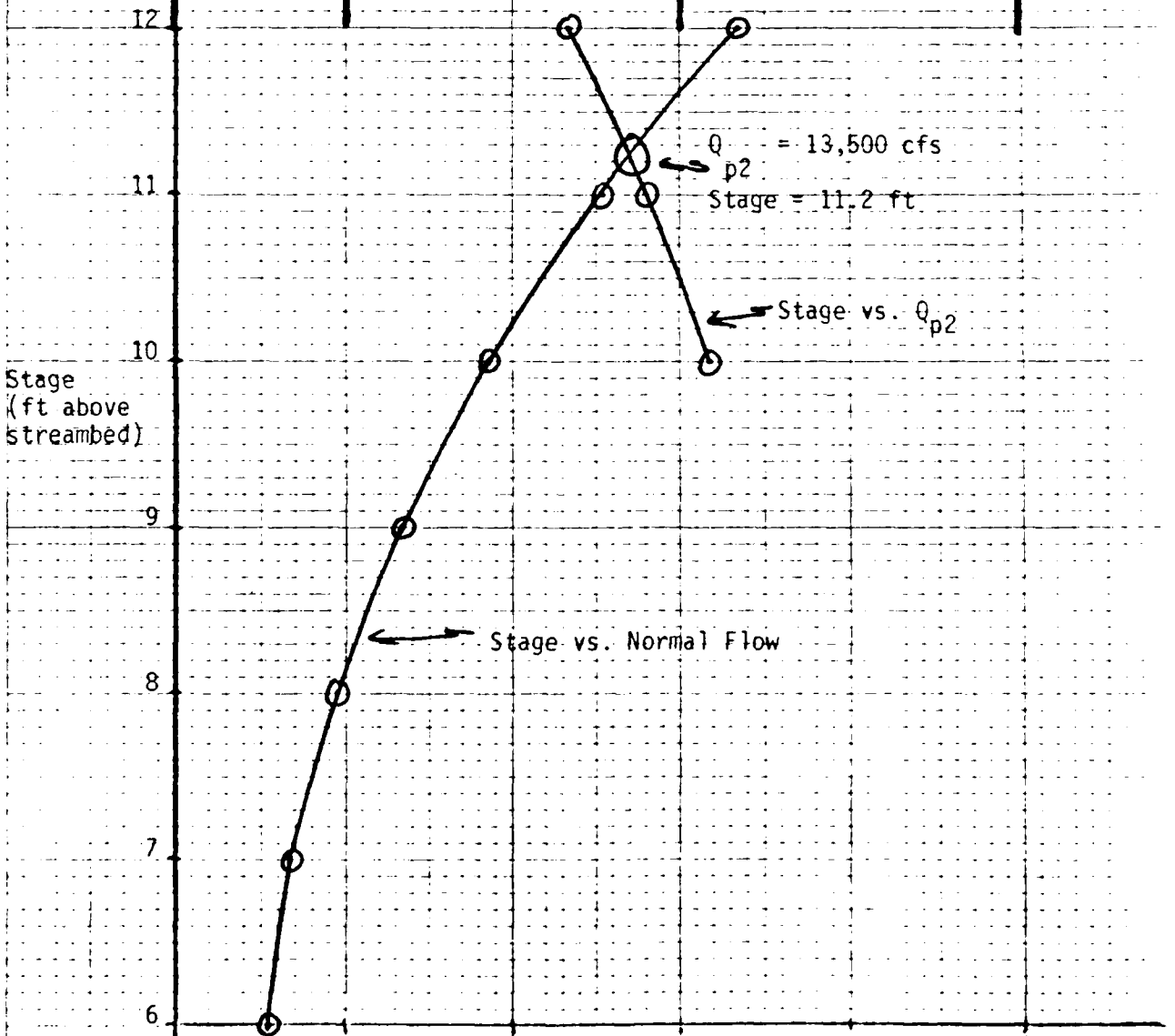
REACH 2 - GRANDY BK. FROM MCQUADE RES. TO MAJOR RD. CROSSING 1

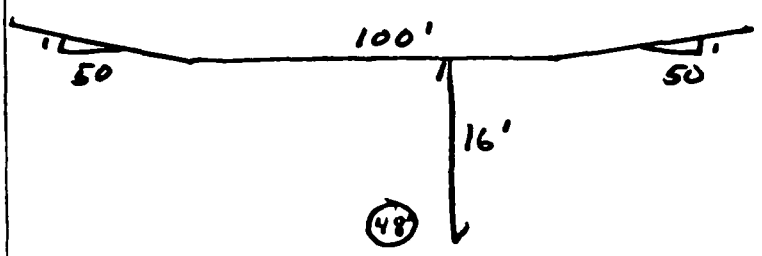
Attenuated Peak Dam Failure Outflow at First Major Road Crossing

TCG, 8/26/79, p. 18

$$Q_{p2} = Q_{p1}\left(1 - \frac{STOR}{87.5}\right) = 22{,}500\left(1 - \frac{STOR}{87.5}\right)$$

Stage (ft above stream)	Area (above 2 ft) (sq ft)	Storage $\left(\frac{\text{Area} \times 2200}{43{,}500}\right)$ (ac ft)	Q_{p2} (cfs)
10	507	26	15,900
11	658	33	14,000
12	831	42	11,700





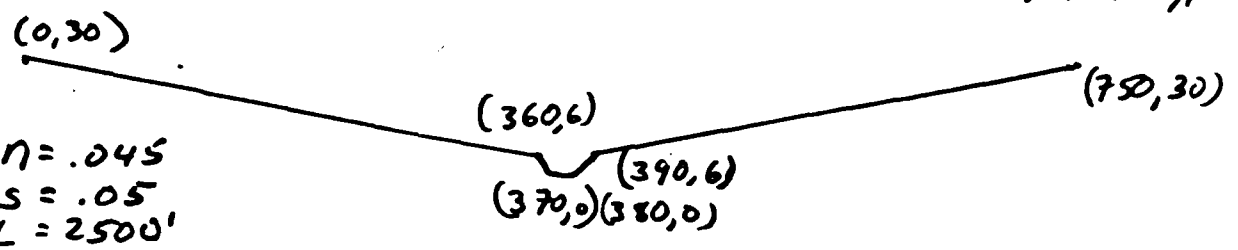
According to the FHA's Hydraulic Engineering circular number 5, the capacity of the culvert is about 250 cfs with the water level at the roadway. The flow over the top of the road could be approximated as:

$$Q = 3.0\,(100)\,h^{3/2} + 2\left[3\,(50h)\,(.5h)^{3/2}\right]$$

The BASIC program on p. 20 calculates a stage/discharge relationship for this cross-section. The pre-failure flow of 240 cfs would result in a water level just below the roadway. The peak dam failure flow of 13,500 cfs would result in a stage about 6 feet over the roadway if the embankment held. The only house which might be affected by backwater from the road is about 6 feet above the road surface. The high velocity flows associated with dam failure would probably damage or destroy this ~~rail~~ road embankment. Storage behind the embankment is not sufficient to attenuate dam failure flows significantly.

The following cross-section is typical for the reach from the first road crossing for the next 2500' until the stream flattens out (based on field notes and USGS topo)

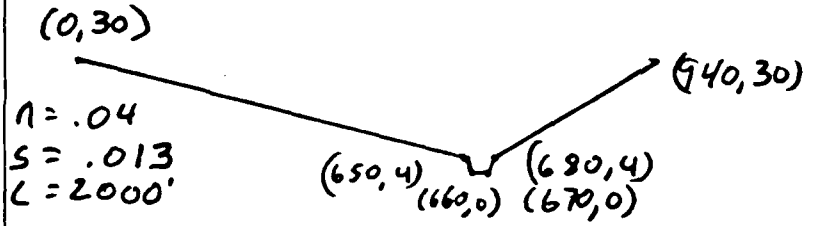
```
LIST
100 REM - PROGRAM TO CALCULATE STAGE/DISCHARGE RELATIONSHIP AT 1ST
110 REM -        MAJOR ROAD CROSSING D/S OF  Fitch RESERVOIR DAM
120 PRINT USING 210:
130 PRINT USING 220:
140 PRINT USING 230:
150 Q1=250
160 FOR H=1 TO 10
170 Q2=3*100*H↑1.5+2*(3*50*H*(0.5*H)↑1.5)
180 T1=Q1+Q2
190 PRINT USING 240:H,T1,Q2,Q1
200 NEXT H
210 IMAGE //"        HEAD                              DISCHARGE"
220 IMAGE " (FEET ABOVE ROAD)                          (CFS)"
230 IMAGE/"                              TOTAL                ROAD                PIPE"
240 IMAGE 08D.2D,14D,18D,17D
250 END

RUN


      HEAD                          DISCHARGE
(FEET ABOVE ROAD)                     (CFS)

                          TOTAL                ROAD                PIPE
        1.00                656                 406                 250
        2.00               1699                1449                 250
        3.00               3462                3212                 250
        4.00               6044                5794                 250
        5.00               9533                9283                 250
        6.00              14012               13762                 250
        7.00              19557               19307                 250
        8.00              26238               25988                 250
        9.00              34124               33874                 250
       10.00              43278               43028                 250
```



A Depth-Normal flow relationship for this reach is given on p. 22. The pre-failure flow of 240 cfs would cause about 2 feet of flow in this reach. The attenuation due to storage in the reach is calculated on p. 23.

The attenuated peak failure flow of 8900 cfs would create a stage of 10.3 feet at the downstream end of this reach. There is no development threatened by flooding on the reach.

Grandy Brook next runs some 2000 feet through a flatter area with a broad floodplain to a small pond. The following typical cross-section for this reach is based on field notes and U.S.G.S topo information:



A Depth-Normal Flow relationship for this reach is given on p. 24. The pre-failure flow of 240 cfs would cause about 2½ ft of flow. The attenuation due to storage in this reach is calculated on p. 25.

P 26

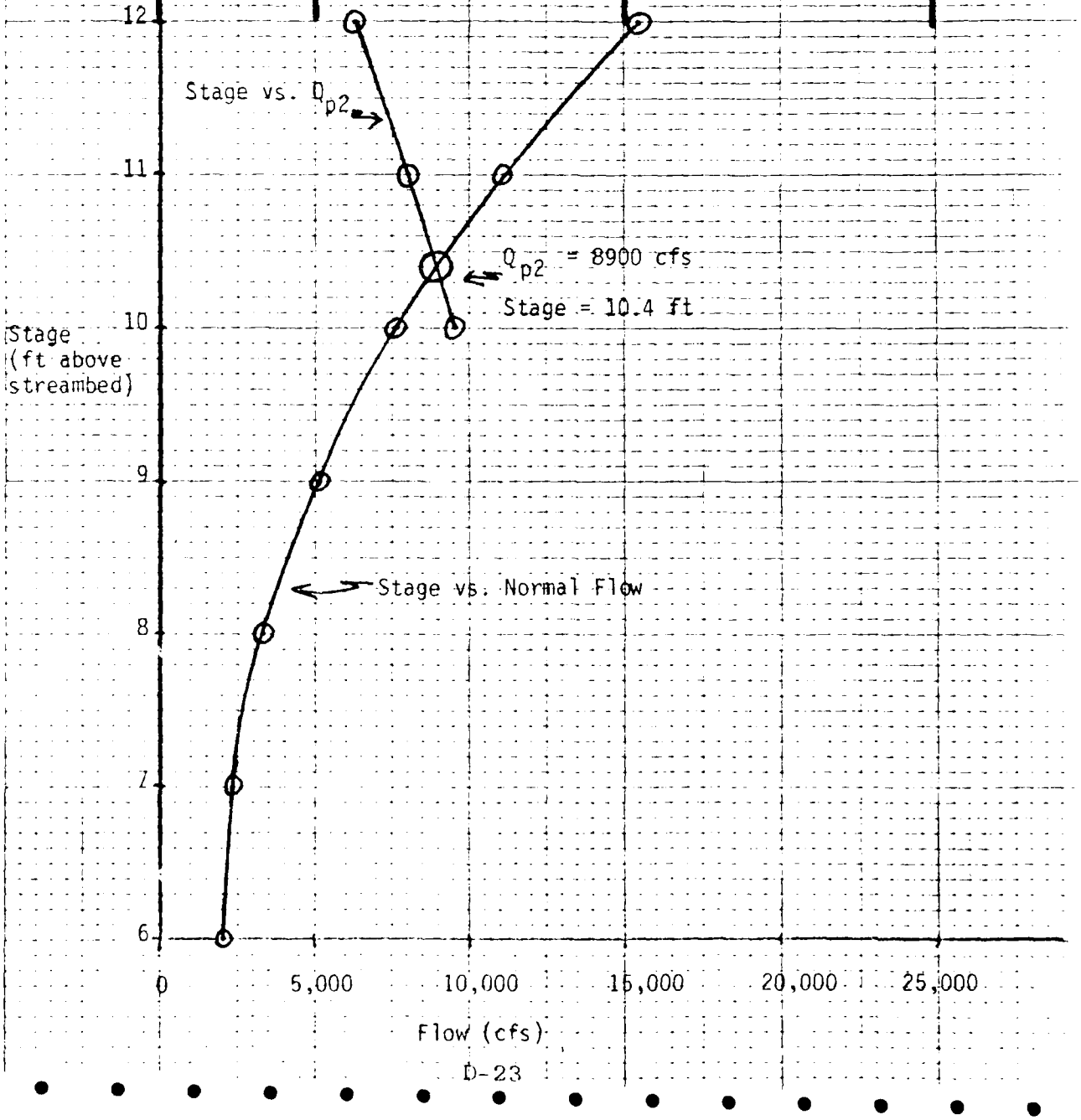
REACH 3 - 1ST MAJOR ROAD CROSSING TO 2500' D/S

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.00	0.0	0.0	0.0	0.0	0.0	0.0
1.00	1.0	11.7	13.8	1.0	10.4	76.9
2.00	2.0	24.5	17.5	2.0	25.0	258.8
3.00	3.0	38.6	21.5	3.0	37.3	542.6
4.00	4.0	53.1	25.6	4.0	49.6	925.8
5.00	5.0	68.0	29.6	5.0	61.9	1447.3
6.00	6.0	83.2	33.7	6.0	74.2	2088.2
7.00	7.0	98.8	37.7	7.0	86.5	2312.4
8.00	8.0	114.7	41.8	8.0	98.8	3733.3
9.00	9.0	130.9	45.8	9.0	111.1	5067.5
10.00	10.0	147.4	49.9	10.0	123.4	7559.3
11.00	11.0	164.2	53.9	11.0	135.7	11038.3
12.00	12.0	181.3	58.0	12.0	148.0	15496.1
13.00	13.0	198.7	62.0	13.0	160.3	21692.9
14.00	14.0	216.3	66.1	14.0	172.6	27961.5
15.00	15.0	234.2	70.1	15.0	184.9	36656.4
16.00	16.0	252.4	74.2	16.0	197.2	45561.2
17.00	17.0	270.8	78.2	17.0	209.5	56956.2
18.00	18.0	289.5	82.3	18.0	221.8	69549.2
19.00	19.0	308.4	86.3	19.0	234.1	83649.2
20.00	20.0	327.6	90.4	20.0	246.4	99619.3
21.00	21.0	347.0	94.4	21.0	258.7	118327.1
22.00	22.0	366.7	98.5	22.0	271.0	139445.4
23.00	23.0	386.6	102.5	23.0	283.3	166571.4
24.00	24.0	406.8	106.6	24.0	295.6	198447.0
25.00	25.0	427.2	110.6	25.0	307.9	211230.0
26.00	26.0	447.8	114.7	26.0	320.2	240099.1
27.00	27.0	468.7	118.7	27.0	332.5	273242.8
28.00	28.0	489.8	122.8	28.0	344.8	309566.3
29.00	29.0	511.1	126.8	29.0	357.1	349952.5
30.00	30.0	532.6	130.9	30.0	369.4	394402.5

Attenuated Peak Dam Failure Outflow 2500 feet Downstream of First Major Road Crossing

$Q_{p2} = Q_{p1}\left(1 - \frac{STOR}{87.5}\right) = 13{,}500\left(1 - \frac{STOR}{87.5}\right)$

Stage (ft above streambed)	Area (above 2 ft) (sq ft)	Storage $\left(\frac{\text{Area} \times 2500}{43{,}500}\right)$ (ac ft)	Q_{p2} (cfs)
10	453	26.0	9500
11	618	35.5	8000
12	813	46.7	6300

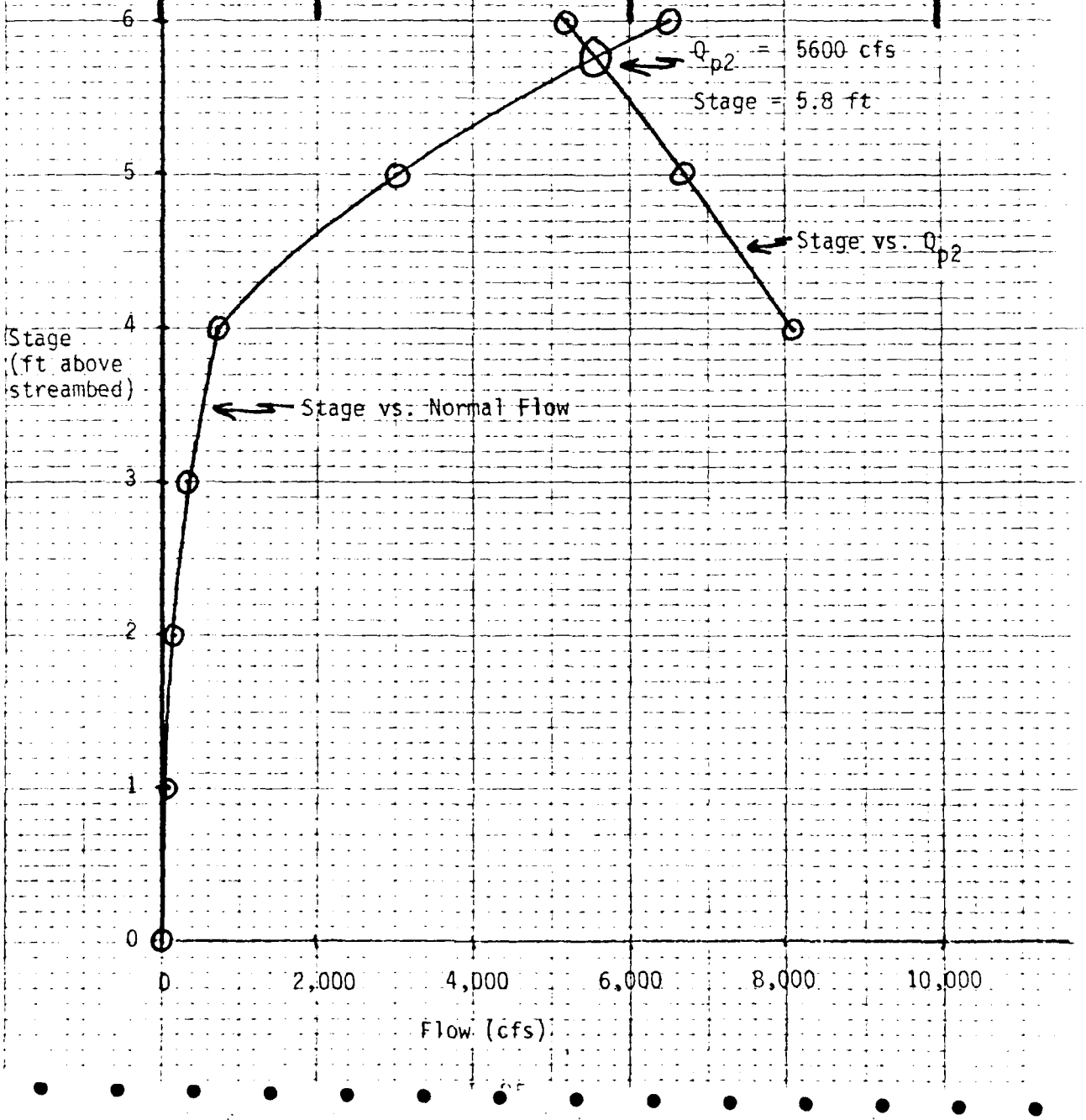


DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.00	0.0	0.0	0.0	0.0	0.0	0.0
1.00	1.0	12.5	15.4	0.8	10.9	46.2
2.00	2.0	30.0	20.8	1.4	38.3	162.8
3.00	3.0	52.5	26.2	2.0	83.6	354.9
4.00	4.0	210.0	291.5	0.7	168.7	716.6
5.00	5.0	512.5	316.6	1.6	706.7	3001.6
6.00	6.0	840.0	341.6	2.5	1530.8	6501.7
7.00	7.0	1192.5	366.6	3.3	2619.0	11123.4
8.00	8.0	1570.0	391.6	4.0	3963.9	16835.3
9.00	9.0	1972.5	416.6	4.7	5564.3	23632.5
10.00	10.0	2400.0	441.7	5.4	7422.3	31523.5
11.00	11.0	2852.5	466.7	6.1	9541.7	40524.9
12.00	12.0	3330.0	491.7	6.8	11927.5	50657.9
13.00	13.0	3832.5	516.7	7.4	14585.5	61947.0
14.00	14.0	4360.0	541.7	8.0	17522.0	74418.7
15.00	15.0	4912.5	566.8	8.7	20743.5	88101.0
16.00	16.0	5490.0	591.8	9.3	24256.9	103022.7
17.00	17.0	6092.5	616.8	9.9	28069.0	119213.3
18.00	18.0	6720.0	641.8	10.5	32186.9	136702.6
19.00	19.0	7372.5	666.8	11.1	36617.6	155520.7
20.00	20.0	8050.0	691.9	11.6	41368.4	175697.9
21.00	21.0	8752.5	716.9	12.2	46446.2	197264.3
22.00	22.0	9480.0	741.9	12.8	51858.3	220250.1
23.00	23.0	10232.5	766.9	13.3	57611.7	244685.6
24.00	24.0	11010.0	791.9	13.9	63713.4	270600.6
25.00	25.0	11812.5	817.0	14.5	70170.6	298025.2
26.00	26.0	12640.0	842.0	15.0	76990.2	326989.1
27.00	27.0	13492.5	867.0	15.6	84179.1	357521.8
28.00	28.0	14370.0	892.0	16.1	91744.5	389652.8
29.00	29.0	15272.5	917.0	16.7	99693.0	423411.3
30.00	30.0	16200.0	942.1	17.2	108031.5	458826.3

REACH 4 - 2500' D/S OF FIRST MAJOR RD. XING TO SMALL POND

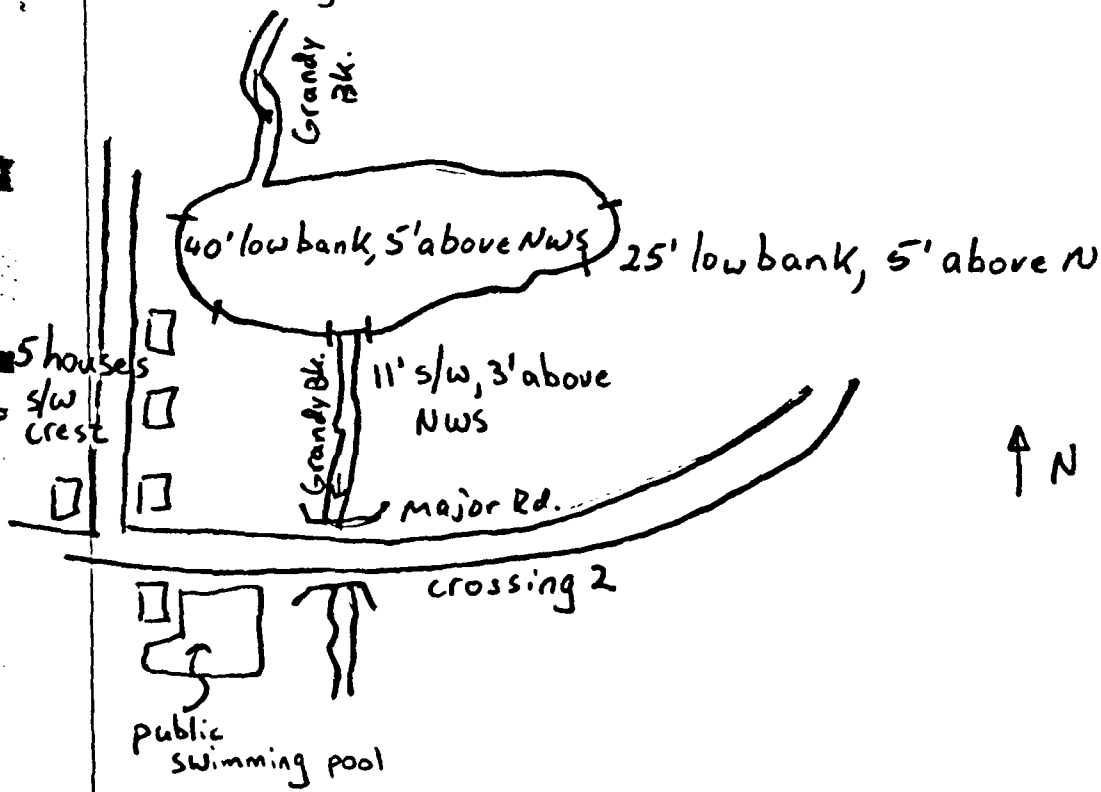
$$Q_{p2} = Q_{p1}\left(1 - \frac{STOR}{87.5}\right) = 8900\left(1 - \frac{STOR}{87.5}\right)$$

Stage (ft above streambed)	Area (above 2.5 ft) (sq ft)	Storage $\left(\frac{\text{Area} \times 2000}{43{,}500}\right)$ (ac ft)	Q_{p2} (cfs)
4	169	7.8	8100
5	471	21.6	6700
6	799	36.7	5200

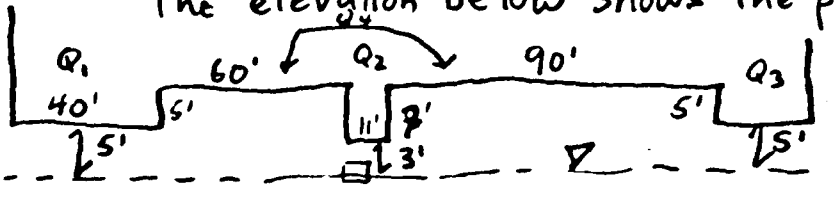


The attenuated peak failure flow of 5600 cfs would create a stage of 5.8 feet at the downstream end of this reach. There is no development threatened by flooding in this reach.

The small pond at the D/s end of this reach has a surface area of less than 1 acre, and thus does not have enough storage to attenuate peak dam failure flows significantly. The sketch below shows this pond and the surrounding area (based on field notes):



The elevation below shows the pond's hydraulic profile:



A stage/discharge relationship for the small dam is given on p. 21. The 5600 cfs peak dam failure outflow would create a stage about 9 feet above the spillway crest. About 920 cfs would go over the spillway, 2130 cfs over the 40' long low bank to the east, 1330 cfs over the 25 ft. low bank to the west, and 1220 cfs over the dam crest. The embankment of this ~~do~~ small pond is in poor shape, and would be damaged or destroyed by this flow.

The 2130 cfs going over the 40' low bank, + some of the ~~1220~~ 1220 cfs over the dam's top would flow through a group of 4-5 houses to the southwest of the pond at about spillway level. There would be noticeable damage to these houses and some potential for loss of life. The potential for loss of life would be particularly high if the high bank to the east of the spillway were to fail, increasing the flow at the houses suddenly.

The dam of this small pond serves to "scatter" dam failure outflow in several directions - and thus probably to attenuate peak failure flows downstream. The exact degree of attenuation is difficult to determine.

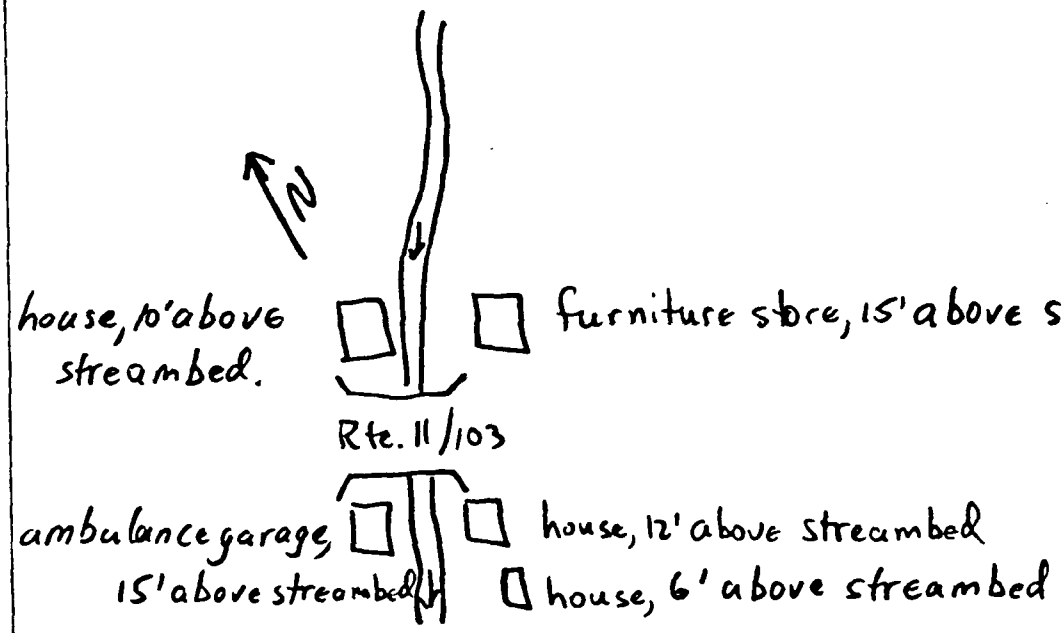
About 200 ft. d/s of the small pond discussed above, ~~the~~ Grandy Blk. has its second road crossing - another residential street in Claremont. This road crossing

RUN

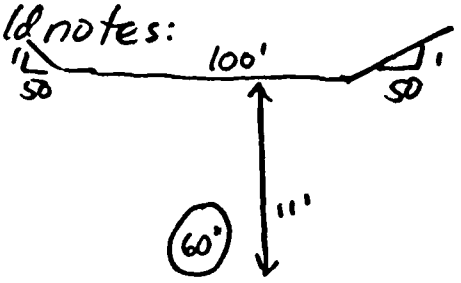
HEAD (FEET ABOVE S/W)	DISCHARGE (CFS) TOTAL	S/W	40' BANK	25' BANK	TOP
1	33	33	0	0	0
2	93	93	0	0	0
3	353	171	112	70	0
4	779	264	317	198	0
5	1315	369	582	364	0
6	1941	485	896	560	0
7	2646	611	1252	783	0
8	3842	747	1646	1029	420
9	5450	891	2074	1296	1188
10	7344	1044	2534	1584	2182

would be overtopped and probably damaged by dam failure flows.

Downstream of this road, Grandy Bk. runs about 2500' to a 3rd major road crossing, N.H. Routes 103 & 11. These reach includes a small reservoir on the brook. The only other development is at the road crossing (based on field notes)



The following elevation of the Rte 103/11 crossing is based on field notes:



According to FHA HEC #5, this culvert would pass about 300 cfs with the water surface at road level. Thus

it seems likely that dam failure flows would be sufficient to overtop, and possibly damage or destroy, this crossing. There is also potential for damage to the houses and stores at the crossing, although the potential for loss of life seems low.

About 200 ft. d/s of this road crossing, Grandy Bk. enters the Sugar River. Dam failure flows would quickly be attenuated in this larger stream.

The downstream effects of the failure of Fitch Reservoir Dam are summarized on page 32.

183 Dam Safety — Fitch Reservoir Dam — TC6, 8/31/79, p.32

Location Number (map)	Location	# of dwellings	level above streambed (ft)	Flow and Stage Before Failure	Flow and Stage After Failure	Comments
–	tailwater	–	–	238 cfs 2 ft.	31,700 17 ft.	
①	McQuade Res. Dam	–	–	240 cfs 1/2 ft. ± over dam	22,500 cfs 10 ft over dam	probably damage or destroy dam
①	houses d/s of McQuade	1 1 3	12-13 8 25+	240 cfs 2 ft	20000 cfs± 13 ft	minor fld. at 1 house severe w/ possible loss of life @ 2nd.
②	1st. Rd. crossing	1	22	240 cfs 16 ft. (at rd.)	13,500 cfs 22 ft. (6 ft. over rd) if embankment holds	serious overtopping of embankment - could be damaged or destroyed
③	small pond	several d/s of pond (4-5)	spillway level	240 cfs 2½ ft. over spillway	5600 cfs 9 ft over spillway	Severe overtopping of banks - possible failure. Flooding to house d/s, w/ some potential of loss of life
③	2nd rd. crossing	–	–	240 cfs –	– –	embankment overtopped
④	Rte. 11-103 crossing	1 1 1 ambulance garage furniture store	6' 10' 12' 15'	240 cfs	– –	potential damage, small chance for loss of life.

Test Flood Analysis

Size Classification: Intermediate, based on the dam height of 40'
Hazard Classification: High

The hazard classification is HIGH due to the potential for serious economic losses and loss of life downstream in the event of dam failure (see chart, p.32).

Test Flood: PMF

Using the COE NED "Maximum Probable Flood Peak Flow Rates", the upstream drainage area of 520 acres (.81 sq. mi.) of mountainous terrain would yield a peak PMF inflow of 2550 cms.

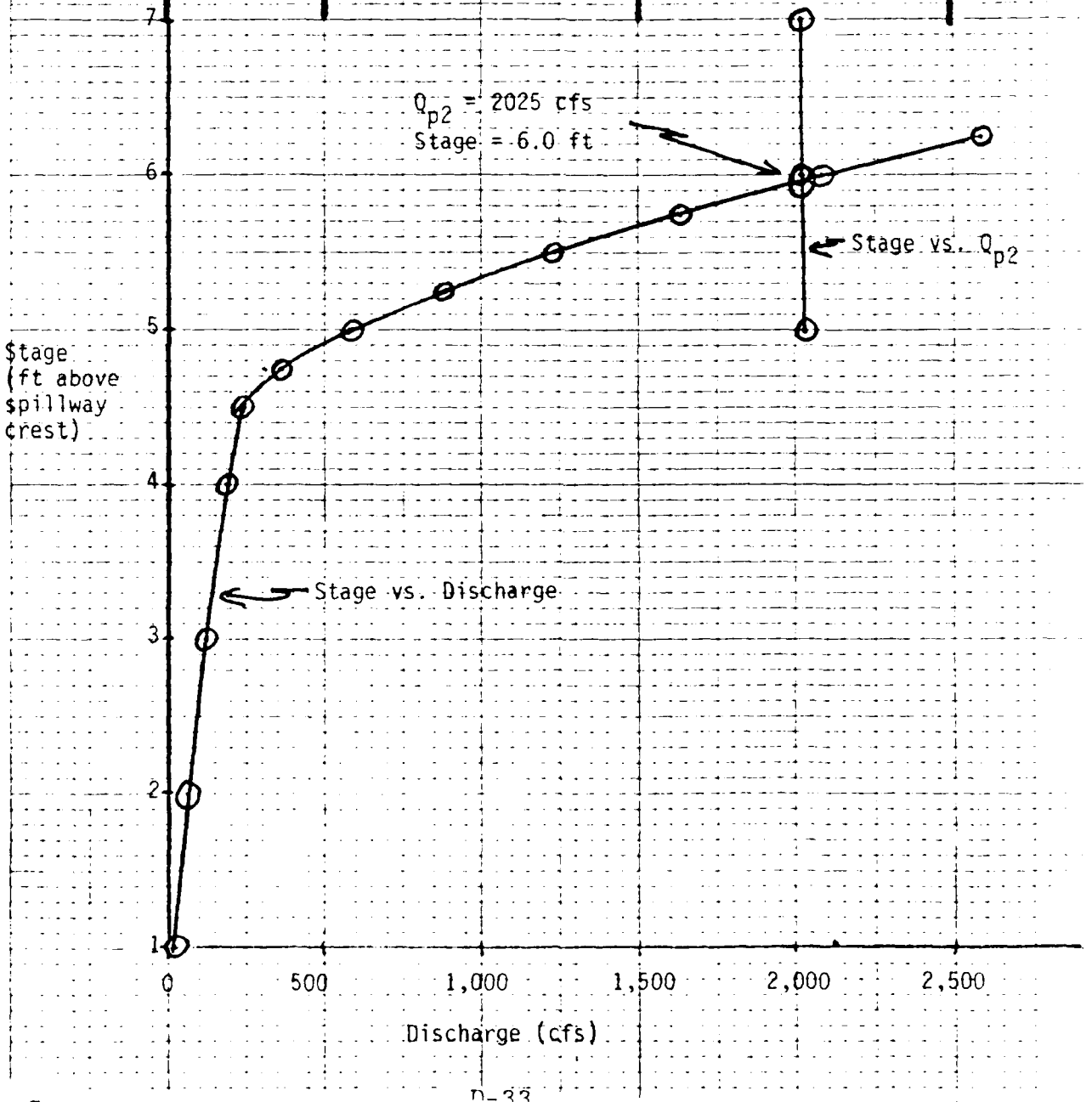
Peak inflow = (.81)(2550) = 2070 cfs.

The attenuation due to storage for the test flood is calculated on p. 34. The peak test flood outflow of 2025 cfs would require a stage 6.' above the spillway crest, 1.5' above the top of the dam.

It is worth noting that the spillway capacity at the dam crest is 238 cfs, only 12% of the test flood.

$$Q_{p2} = Q_{p1}\left(1 - \frac{STOR}{19''}\right) = 2070\left(1 - \frac{STOR}{19''}\right)$$

Stage (ft above spillway crest)	Surcharge storage (ac-ft)	Surcharge storage (inches of runoff)	Q_{p2} (cfs)
0	0	0	2070
5	15	.35	2030
6	18	.41	2025
7	21	.48	2020



For the purpose of comparison with spillway capacity, we will estimate the 100 yr. inflow to the reservoir using USGS WRI 78-47, Denis LeBlanc's "Preliminary Relations for Estimating Peak Discharges on Rural, Unregulated Streams."

$$P_{100} = .55\, A^{1.05}\, s^{.56}\, I^{2.72}$$

A = drainage area, sq. mi. = .81

I = Max. 2yr. 24 hr. precipitation = 2.8"

s = u/s slope, ft/mile = 660

= 276 cfs

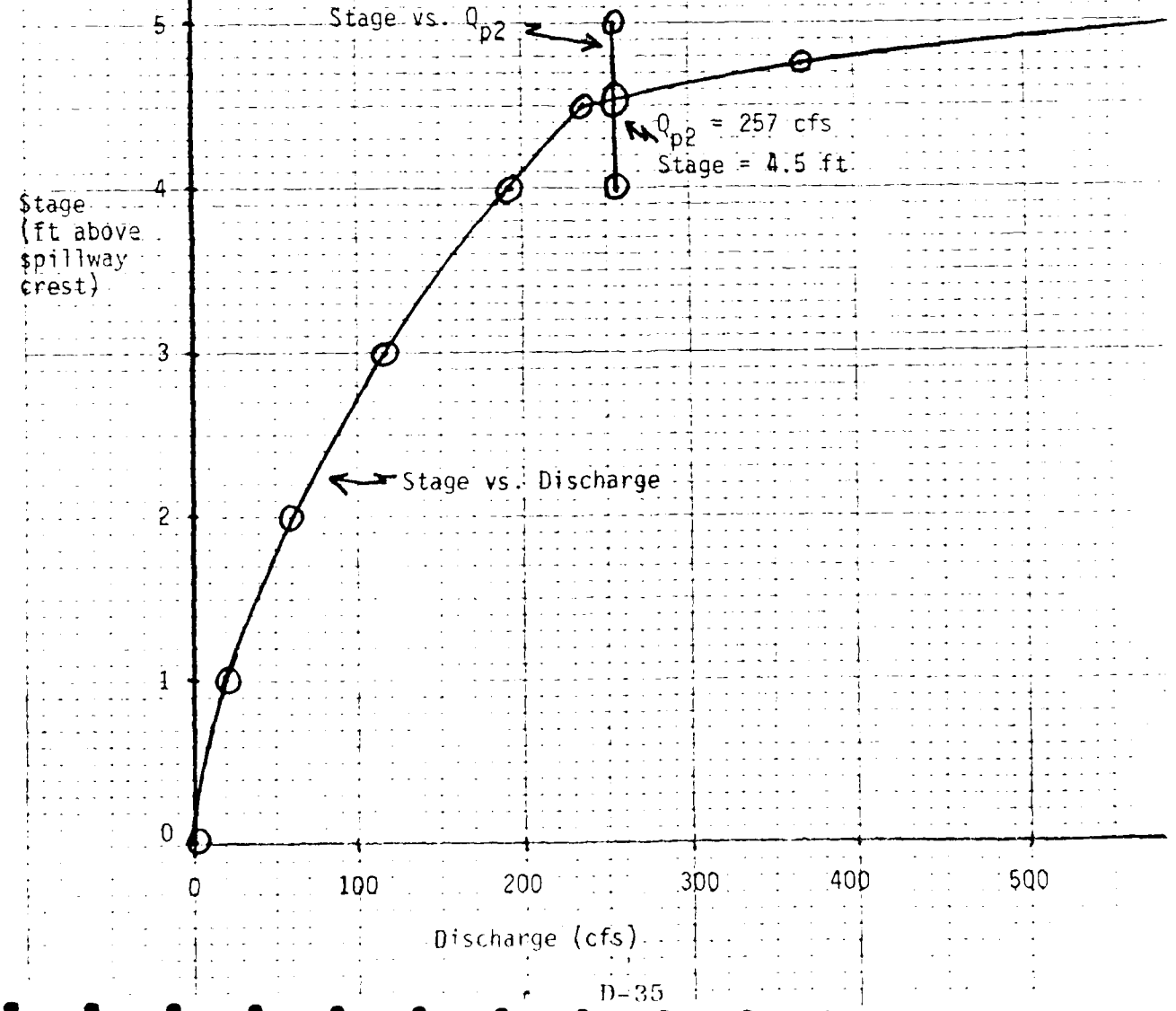
The attenuated 100 year reservoir outflow is calculated on p. 36. The attenuated peak outflow of 257 cfs exceeds the spillway capacity by 8%, and slightly over tops the dam crest.

Degree of Overtopping at 1/2 PMF

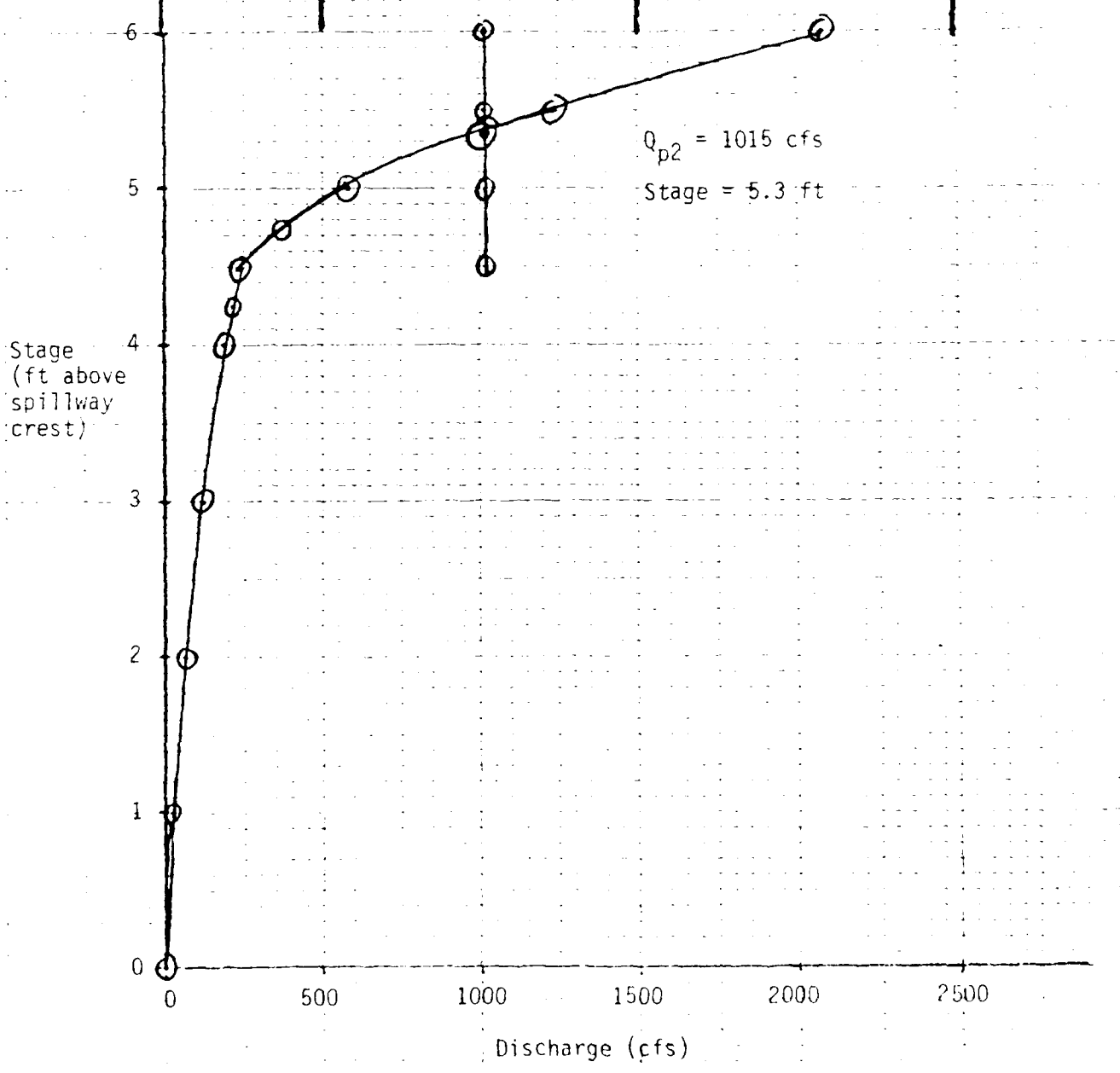
The 1/2 PMF inflow = 1/2 (2070) = 1035 cfs The attenuation due to storage for this inflow is calculated on P. 37. The outflow of 1015 cfs would be 325 cfs over the spillway, and 690 cfs over the dam crest, which would be overtopped by slightly over .8 foot.

$$Q_{p2} = Q_{p1}\left(1 - \frac{STOR}{4.75}\right) = 276\left(1 - \frac{STOR}{4.75}\right)$$

Stage (ft above spillway crest)	Surcharge storage (ac ft)	Surcharge storage (inches of runoff)	Q_{p2} (cfs)
4.5	13.5	.31	25[illegible]
5	15	.35	256

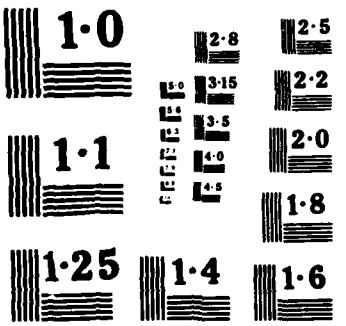


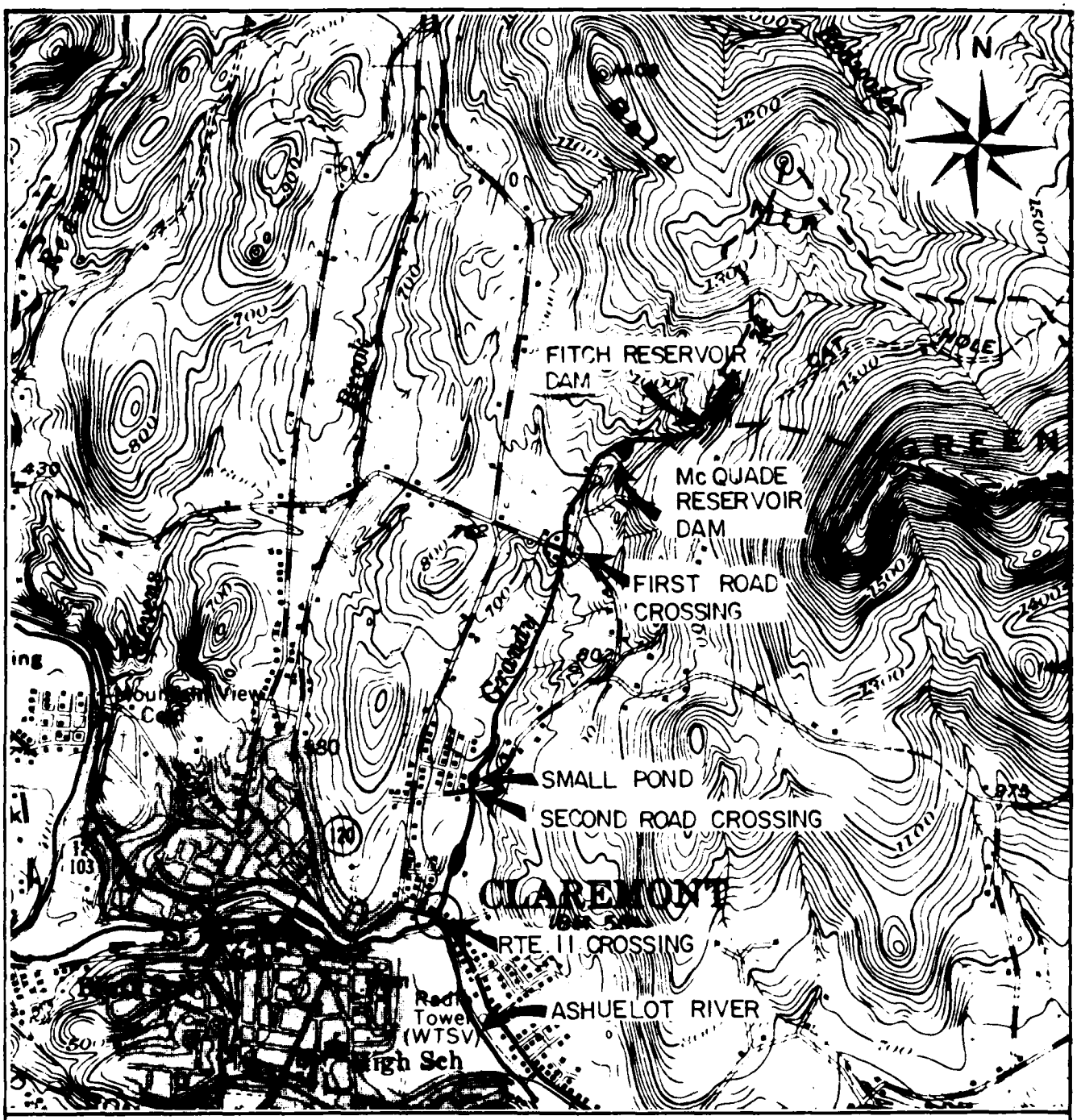
Stage (ft above spillway crest)	Surcharge Storage (ac ft)	Su charge Storage (inches of runoff)	Q_{p2} (cfs)
4.5	13.5	.31	1018
5	15	.35	1016
5.5	16.5	.38	1014
6	18	.41	1013



AD-A156 318 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS 2/2
FITCH RESERVOIR DAM (.. (U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV DEC 79

UNCLASSIFIED F/G 13/13 NL





– SCALE –

0 1/4 1/2 1 (MILES)

FROM: USGS CLAREMONT - N.H. QUADRANGLE MAP

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

DOWNSTREAM HAZARD MAP

FILE No. 2327

FITCH RESERVOIR DAM — CLAREMONT, NEW HAMPSHIRE

SCALE AS NOTED

DATE SEPT 1979

APPENDIX E

INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

STATE	IDENTITY NUMBER	DIVISION	STATE	COUNTY	COUNTY CODE	STATE	COUNTY	COUNTY CODE	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE DAY	MO	YR
NH	142	NED	NH	019	02				FITCH RESERVOIR DAM	4324.0	7218.8		09	OCT 79

POPULAR NAME	NAME OF IMPOUNDMENT
JOHNSON RESERVOIR DAM	FITCH RESERVOIR

REGION	BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	DIST FROM DAM (MI.)	POPULATION
01	08	GRANDY BROOK	CLAREMONT	2	14221

TYPE OF DAM	YEAR COMPLETED	PURPOSES	STRUCTURAL HEIGHT (FT.)	HYDRAULIC HEIGHT (FT.)	IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	IMPOUNDING CAPACITIES NORMAL (ACRE-FT.)	DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
PGRE	1888	8	40	40	87	74	NED	N	N	N	N	

REMARKS

DAM MAP	SPILLWAY LENGTH	SPILLWAY TYPE	SPILLWAY WIDTH (FT.)	MAXIMUM DISCHARGE (CFS)	VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (MW)	POWER CAPACITY PROPOSED (MW)	NAVIGATION LOCKS NO	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	LENGTH (FT.)	WIDTH (FT.)
1	300	U	6	238												

OWNER	ENGINEERING BY	CONSTRUCTION BY
TOWN OF CLAREMONT		

REGULATORY AGENCY			
DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NHWRB	NHWRB	NHWRB	NHWRB

INSPECTION BY	INSPECTION DATE DAY	MO	YR	AUTHORITY FOR INSPECTION
GOLDBERG ZOINO DUNNICLIFF & ASSOC	21	AUG	79	PL92-367

REMARKS

END

FILMED

8-85

DTIC